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Dynamics of Construction Firms' Organisational Capability and Strategy through Solid Waste Public-Private Partnership Arrangement in Japan

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Summary

This study examined the influence of public–private partnership (PPP) – or, more specifically, private finance initiative (PFI) – arrangements in relation to open and service innovation in construction firms in Japan. The Japanese government is increasingly requiring PPP/PFI arrangements for procuring and managing social infrastructure, such as airports, public facilities (e.g. government offices, schools and public housing) and waste treatment facilities, owing to pressure to reduce the financial burden on central and municipal governments.

From the innovation studies perspective, construction firms need to foster both service and open innovation to bring about the institutional changes required for PPP/PFI arrangements. In terms of service innovation, since the scope of PPP/PFI projects is much wider than that of conventional construction projects, the role of a construction firm as a leading company in a consortium is normally wider too. To undertake these PPP/PFI projects, construction firms must collaborate with other companies, such as design and maintenance firms, to deliver a wide range of services through special purpose vehicles (SPVs).

However, studies on the effects of PPP/PFI arrangements have mainly focused on evaluating projects – that is, determining whether PPP/PFI is effective for providing public services, which depends on the project. Although a few studies have focused on the capability development of construction firms through PPP/PFI arrangements, most of these studies have also conducted short-term and project-based analyses (e.g. London Heathrow Terminal 5 project and the London Olympics). There is still little understanding of the long-term dynamics of the evolution of the capabilities of a project-based firm itself. This dissertation accomplishes the research agenda in threefold: the historical analysis, empirical analysis, and appreciative theorising.

Using integrated qualitative and quantitative approaches, this study analysed three plant engineering companies that conduct waste management PPP/PFI projects – Hitachizosen, Ebara and Takuma – using Eisenhardt's approach (Martin and Eisenhard, 2010; Tsoumada, 2021). To analyse how their

organisational capabilities evolved, indicators were introduced. For quantitative analysis, we developed an original PPP/PFI project database based on the results of 1,437 bids for PPP/PFI projects. The bidding information included contract-based project details, the list of member companies and their roles, the selection committee's evaluation results and the summary of proposals. Data such as patent data, R&D expenses and the focal companies' sales and profit were also collected. For qualitative analysis, interviews with ten experts from plant engineering companies, municipalities and waste management associations were conducted.

The three companies were analysed by considering their performance and accumulation of three organisational capabilities: technological capability, project capability, and collaborative capability under their strategy. The long-term historical analysis of the companies revealed the strategic differences between their capability development towards innovation under the PPP/PFI arrangement. A holistic capability accumulation model was proposed and examined using case studies of three leading Japanese construction firms in the field of waste-to-energy PPP/PFI projects. Collaborative capability, it was found, could be a key factor for construction firms in expanding their service field. Moreover, collaboration with competitors (co-opetition) is important to stand out in the PPP/PFI market and the conditions under which co-opetition works effectively are assumed.

Table of Contents

Abbreviations

PPP	public–private partnership
PFI	private finance initiative
SPV	special purpose vehicle
BOT	build-own-transfer
BTO	build-transfer-operate
BOO	build-own-operate
DBO	design-build-operate
VFM	value for money
SWM	solid waste management
3R	Reduce, Reuse and Recycle
CoPS	Complex Product System
O&M	operation and maintenance
CAPEX	capital expenditures
R&D	research and development
IPC code	International Patent Classification
FI code	File Index code
CAGR	compound annual growth rate
JPY	Japanese yen
USD	United States dollar
R.Q	research question

Chapter 1 Introduction

1.1 Motivations of this Study

This dissertation examined construction firms with higher value-added services (service innovation) and their services through the framework of Public Private Partnership (PPP) and Private Finance Initiative (PFI) projects in Japan. This dissertation aimed to identify the dynamics of organisational capabilities for expanding collaboration with companies in other fields (open innovation).

The Japanese government has increasingly required Public–Private Partnership (PPP) and Private Finance Initiative (PFI) arrangements for procuring and managing social infrastructures, such as airports, public facilities (e.g. government offices, schools, and public housing) and waste treatment facilities, owing to pressure to reduce the financial burden on central and municipal governments. In 2018, the Cabinet Office set a goal for introducing PPP/PFI projects (from 2013 to 2022) totalling JPY 12 trillion, which is almost twice the amount set in 2013 (Cabinet Office, 2013, 2018). Guidelines for prioritising the introduction of various PPP/PFI arrangements were introduced in 2015 (Cabinet Office, 2015). These guidelines recommend that local governments, which represent populations of more than 200,000, consider utilising PPP/PFI to build and operate public facilities.

PPP is loosely defined as a cooperative institutional arrangement between public- and private-sector actors. PFI is one type of PPP collaboration that is based on long-term infrastructure contracts led by private actors. PFI was first introduced in the United Kingdom in 1992 and in Japan in 1999 to harness the management skills and commercial expertise of the private sector and bring discipline to the delivery of public infrastructure (HM Treasury, 2012). PFI-type PPPs involve many forms of contractual arrangements, such as BOT (build-own-transfer), BTO (build-transfer-operate) and BOO (build-own-operate) (for more details, see Savas, 2000). In this study, however, we simply define PPP/PFI as a 'project that generally involves the design, construction, financing, and maintenance and operation of public infrastructure or a public facility led by the private sector under a long-term contract' (Campbell, 2001).

PPP/PFI arrangements foster the involvement of private companies, such as construction companies, in roles conventionally assumed by public authorities, such as investment, project management and operation, and maintenance service management. Such PPP/PFI arrangements are expected to improve public service quality and reduce costs. As shown in Figure 1.1, PPP/PFI projects include a wide range of services from private firms based on long-term contracts.

In conventional public-driven projects, the public sector manages the entire life cycle of the public facilities, including planning, design, finance, construction, operation, and maintenance. Private firms are partly involved at some stage in this life cycle, such as design, construction, and maintenance, separately. Once construction companies have completed their work and have passed the final inspection stage, they will usually only take minimal responsibility for the facility in question. Although some maintenance and operation works are outsourced to private firms, the roles of private contractors are generally strictly assigned according to the specifications of the arrangement.

On the contrary, in PPP/PFI projects, the service-related life cycle of public facilities is included in a long-term PPP/PFI contract, such as design, finance, construction, operation, and maintenance, transferring risk and return for private investment to the CAPEX. A long-term commitment to a PPP/PFI contract based on output procurement encourages private companies to undertake innovative actions towards improving the lives of the infrastructure project. Furthermore, PPP/PFI projects have forced suppliers – in many cases, construction companies – to set up special purpose vehicles (SPVs). These act as key coordinating agencies, taking on financial, design and operational responsibilities for the public facilities.

A private developer finances and builds a facility and, upon completion, transfers legal ownership to the sponsoring government agency. The agency then leases the facility back to the developer under a long-term lease, during which period the developer operates the facility and has the opportunity to recover his investment and earn a reasonable return from user charges and commercial activity (Savas, 2000).

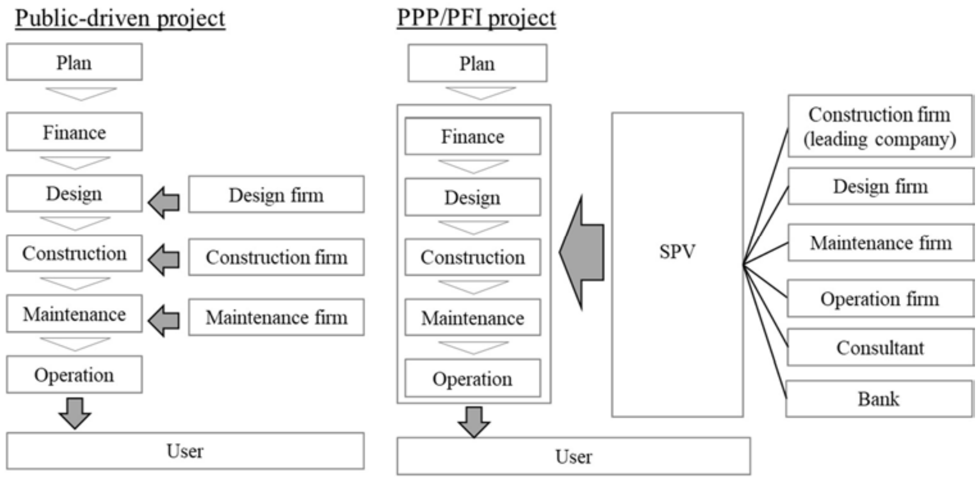

Figure 1.1: The difference in the scope of a public-driven project and a PPP/PFI project

Source: Author's modification based on Cabinet Office (2014)

From the innovation studies perspective, construction firms need to foster both service and open innovation to bring about the institutional changes required for PPP/PFI arrangements. In terms of service innovation, since the scope of PPP/PFI projects is much wider than that of conventional construction projects (Cabinet Office, 2014), the role of a construction firm as a leading company in a consortium is normally wider too. To undertake these PPP/PFI projects, construction firms must collaborate with other companies, such as design and maintenance firms, to deliver a wide range of services through SPVs (Cabinet Office, 2014).

However, studies on the effects of PPP/PFI arrangements have mainly focused on evaluating projects – that is, determining whether PPP/PFI is effective for providing public services, which depends on the project (Hodge and Greve, 2007; Treasury Committee, 2011). Although some studies have focused on the capability development of construction firms through PPP/PFI arrangements, most of these studies have also conducted short-term and project-based analyses (e.g. London Heathrow Terminal 5 project [Davies and Brady, 2016; Davies et al., 2016] and the London Olympics [Worsnop et al., 2016]). There is still little understanding of the long-term dynamics of the evolution of the capabilities of a project-based firm itself and influence of partner-companies in the business eco-system.

Davies and Brady (2016) defined project capability, which is distinguished from the dynamic capability of a project-based organisation. There are various ways for a project-based firm to accumulate capabilities, such as through project-to-project learning or within groups of firms in the business ecosystem. In this dissertation, we highlight bringing project capabilities from outside the firm as collaborative capability to examine the capability for open innovation more clearly.

1.2 Research Objective

This study aimed to reveal how Japanese construction firms have improved their organisational capability under the strategy to provide a broader range of services by expanding their cooperation with various other firms under the PPP/PFI procurement arrangement. To this end, we proposed indicators, and we clarified why the accumulation of organisational capability leads to improved firm performance.

1.3 Research Questions

The study was aimed at filling the aforementioned knowledge gaps by addressing the following questions:

R.Q.1: How have construction firms' organisational capability evolved to provide PPP/PFI services for the public sector?

R.Q.2: Why do construction firms' organisational capabilities evolve through PPP/PFI arrangements under their strategy?

To address these questions, we conducted a multiple case study of three Japanese construction companies that are the most experienced in the field of waste management PPP/PFI projects: Hitachizosen, Ebara and Takuma.

Consequently, we proposed a model of capability development towards service and open innovation consisting of three particular organisational capabilities: technological capabilities, project capabilities and collaborative capabilities in the case of a construction firm which is a key factor in PPP/PFI. The model can be seen as ideal for understanding and comparing cases of long-term capability accumulation of project-based firms, especially with regard to providing services that meet the public's needs.

1.4 Structure of the Thesis

The structure of the thesis is presented on Figure 1.2. The research objective is to reveal the innovation system of waste-towards Japanese construction firms' accumulation of organisational capability to provide a broader range of services through expanded cooperation with various other firms under the PPP/PFI procurement arrangement.

Chapter 1 provides introduction of this thesis. In Chapter 2, background of this study is described. Chapter 3 shows theoretical background, analytical framework and methodology. Chapter 4 express dynamics of construction firms' organisational capability. Chapter 5 consists of conclusion and implication.

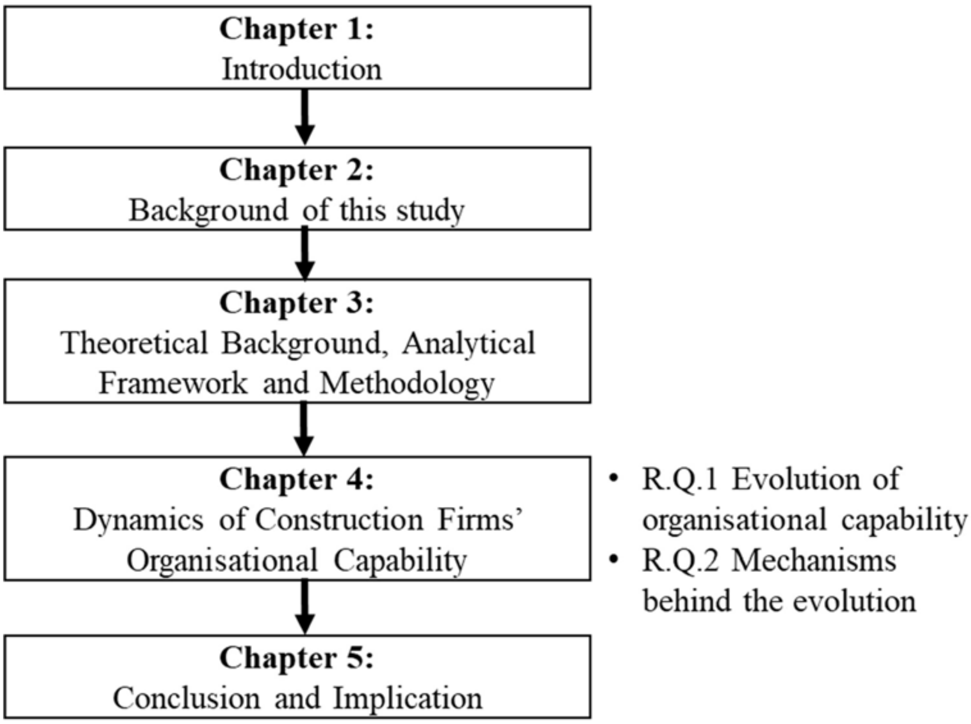

Figure 1.2: Structure of this thesis

Chapter 2 Background

2.1 Public–Private Partnerships

2.1.1 Definition of Public–Private Partnerships

Public–private partnerships (PPP) are loosely defined as cooperative institutional arrangements between public and private sector actors. The phrase has garnered wide interest, and people discuss it from various perspectives. For example, Hodge and Greve (2007) divide PPP scholars between those who view PPPs as a tool of governance and those who think they are a 'language game' (Teisman and Klijn, 2001; 2002 cited by Hodge and Greve, 2007).

On the one hand, PPPs are categorised into five families in terms of governance, which are institutional cooperation for joint production and risk sharing; long-term infrastructure contracts led by private actors, such as private finance initiative (PFI)-type PPPs; public policy networks that emphasise loose relationships between stakeholders; civil society and community development in which partnership symbolism is used for cultural change; and urban renewal and downtown economic development (Hodge and Greve, 2007).

On the other hand, the broad alternative view on PPPs is that they are a language game. For instance, Savas (2000) argues that the expression 'public–private partnerships can invite more people and organisations to join the debate on private participation and enable private actors to acquire a market share of public service provision. By contrast, 'contracting out' and 'privatisation' are expressions that quickly generate opposition.

In the field of solid waste management (SWM), numerous studies consider private participation from various angles. Although the private sector has been involved in a wide range of SWM systems for many decades, the demand to expand the participation of the private sector continues to increase (Ahmad and Ali, 2004; Eguchi, 1999; Reddy, 2011). Private participation has various types, as discussed above. SWM is related to people's daily life, so PPPs are often discussed in the context of civil society and community involvement (Ahmad and Ali, 2004). However, this study focuses on a PFI-type PPP as the real project implementation because a formal PPP arrangement for waste treatment infrastructure has increased in practice in the last two decades.

PFI was first introduced in the UK in 1992 as a means to harness the management skills and commercial expertise of the private sector and to bring discipline to the delivery of public infrastructure (HM Treasury, 2012). PFI-type PPPs involve many forms of contractual arrangements, such as BOT (build-own-transfer), BTO (build-transfer-operate) and BOO (build-own-operate) (see Savas (2000) for more detail). In this study, however, we simply define PPP as 'a PPP project generally involves the design, construction, financing, and maintenance (and in some cases operation) of public infrastructure or a public facility by the private sector under a long-term contract' (Campbell, 2001, cited in Hodge and Greve, 2007). Over the last 20 years, PFI-type PPP arrangements have widely spread and are now used across a broad range of sectors.

2.1.2 Public–Private Partnership Theories

In general, regardless of the types of institutional arrangements of infrastructure projects, such as public driven or PPPs, infrastructure projects are complex production systems that are composed of multidisciplinary tasks and thus require a wide range of expertise. That is, infrastructure projects are performed under high levels of division of labour, such as engineering design and environmental assessment. On the positive side, the advanced specialisation of project participants can foster efficiency in each task and stage of the project from design to operation. On the negative side, each task and stage can be disintegrated in terms of knowledge sharing.

Traditional infrastructure projects, which can be typified as public-driven projects, have received a series of criticisms in terms of poor project implementation, such as miscalculation of the project period, cost overruns on construction, poor design and build quality and high maintenance and operation costs (Robinson et al., 2010). The PPP arrangement is introduced to infrastructure projects to exploit private finance, effective management and the high expertise of the private actors involved. In theory, PFI-type PPPs are expected to deliver low whole-life costs and high-quality public service, which essentially mean 'value for money (VFM)' [1] in the provision of public infrastructure (Hodge and Greve, 2007; Treasury committee, 2011) through the active participation of the private sector.

This sub-section reviews the conceptually positive effects of PFI-type PPPs compared with those of public-driven conventional infrastructure projects in terms of three perspectives on PFI-type PPPs: the increasing role of the private sector, clear division of responsibility between the public and private sectors, and long-term contracts.

First, the expansion of the role of private participation encourages the private sector to apply its advantages in its areas of expertise to public projects. Partnerships are established because both public and private sectors have specific areas of expertise, and if these specialities are combined, the end result will be desirable for all (Vailancourt Rosenau, 2000 cited in Hodge and Greve, 2007). Thus, both public and private sectors basically share the tasks involved in a project on the basis of who can more effectively perform the role. In general, the private sector has better ability to effectively manage projects than the public sector, and its high technological expertise helps improve project performance.

SWM infrastructure clearly features the characteristics of public goods and traditional public sector conduct, and it also manages the entire process of projects, such as finance, design, construction, operation and maintenance. Usually, private companies participate only in the construction stage under the supervision of the public. A part of operation and maintenance work based on a short-term contract if the public sector needs it. On the contrary, the private sector is mandated to perform most of the conventional role of the public sector under PFI-type PPP procurements. In many cases of PPP projects, local authorities play a central role before the contract but only a limited role after the contract, such as by supporting and monitoring private companies. As a

[1] The National Audit Office (NAO) in the UK defines VFM as being 'the optimal use of resources to achieve intended outcomes'. 'Optimal' means 'the most desirable possible given expressed or implied restrictions or constraints'. VFM is not about achieving the lowest initial price (NAO, 2004).

consequence of the introduction of PFI-type PPPs, public authorities assume that they could use more resources of private companies (e.g. staffing, funding and equipment) and thus reduce the burden on central/local government budgets (Eggerth, 2005; Hodge and Greve, 2007). From the standpoint of private companies, more business opportunities are available in the significant public service market.

Overall, the expansion of private participation associated with effective management and high technological expertise should, in theory, contribute to the reduction of total project costs and an increase in public service performance. Then, it should ultimately lead to less burden on and high satisfaction for taxpayers.

The second feature of PFI-type PPPs is the clear allocation of responsibilities, such as tasks and potential risks, particularly risk allocation between the public and private sectors. The clarification of risks across participants can facilitate active and autonomous private sector participation in public services.

In conventional infrastructure procurement, the works and autonomy of private companies are limited under the umbrella of public authorities. Although some tasks, such as construction, are delegated to private actors, their activities are specified in the planning stage by public authorities. Once private contractors have completed their work and have passed the final inspection stage, they will usually only take minimal responsibility after this period. Although some maintenance and operation works are outsourced, the roles of private contractors are generally strictly assigned according to the specifications of each contract. Private actors have no room to actively improve their performance in their given jobs.

Moreover, hybrid public–private sector organisations, the so-called third sector, fail to integrate the advantages of the private sector, such as its management skills, because of the ambiguous role sharing between the public and private spheres without a clear risk allocation set in place (Hiyoshi, 2009). Many third-sector projects are bankrupted because they follow optimistic business plans with an unclear allocation of managerial responsibility.

By contrast, in the case of PPPs, the scope and allocation of risks are intended to be clearly determined from the beginning of the project, and this would therefore encourage private companies to proactively play their role. Private participants can have the autonomy in attempting to improve the performance of tasks to some extent under predictable risks.

Third, a long-term commitment to a PPP contract based on output procurement encourages private companies to undertake innovative actions towards improving the whole life of the infrastructure project. A main problem in conventional procurement is a project culture to see the responsibilities for design, construction, operation and maintenance separately. Decisions on capital investment therefore normally focus only on construction costs and doing so results in high operating and maintenance expenditure over the life cycle of the infrastructure; in turn, the effectiveness of the whole-life cost is influenced (Robinson et al., 2010). Furthermore, short-term contracts in operation and maintenance pose difficulties in the stable investment and management of facilities and the training of labour in the long term. This scenario can potentially lead to inefficiency in the operation of infrastructure.

By contrast, PPP procurement has an institutional advantage in terms of economic sustainability. PPP procurement often embraces the whole life cycle of a project, including design, construction, operation and maintenance.

Specifically, long-term PPP procurement, with the contract normally running for 20 to 30 years, induces private bidders to propose the cost-saving plans of the whole life cycle of the infrastructure to be selected based on the plan at the bidding stage. If the procurement process is sufficiently competitive, PPP projects should, in theory, result in low prices for the public sector. Moreover, the private sector should, in theory, be able to achieve high efficiency and value for money in service delivery because of innovation pressure to reduce whole-life costs, risk management and level of competition (Ibid.). If the benefits of whole life costing work, building design would be reasonably expected to make use of innovations that will result in high-quality buildings or those that will last long in good condition (Treasury committee, 2011).

2.1.3 Evidence of Public-Private Partnerships

Although PPP theories emphasis that PPPs could lead to lower whole-life costs and better quality of public service, which is represented as higher VFM, the evaluation of PPPs has delivered contradictory evidence as to their effectiveness in reality.

Actually, the private finance cost is more expensive than government borrowing (Treasury Committee, 2011; Hodge and Greve, 2007) and the gap in financial costs were increased after the economic crisis. According to the Treasury Committee (2011), the cost of capital for typical PFI projects currently stands at over 8%, which is double the long-term government gilt rate of approximately 4%. Thus, PPPs are expected to offset this higher financial cost by means of more effective management of infrastructure associated with innovative activities by private companies compared to public sector actors.

However, evidence gathered by previous studies (Treasury Committee, 2011; Hodge and Greve, 2007) could not show a clear improvement of VFM in PPP projects compared to conventional projects. For example, Hodge and Greve (2007) and the Treasury Committee (2011) described several examples from developed countries which show conventional results.

Hall (1998, cited in Hodge and Greve, 2007) suggests that the early PFI projects in the United Kingdom could achieve significant savings overall for road projects and two prison contracts that generated about 10% savings compared to publicly financed prisons. Similarly, the analysis of 29 business cases by Arthur Anderson and Enterprise LSE (2000, cited in Hodge and Greve, 2007) found 17% cost savings. Moreover, recent reports from Mott-Macdonald (2002, cited in Hodge and Greve, 2007) and the National Audit Office (2003, cited in Hodge and Greve, 2007) identify PPPs as being delivered on-time and on-budget far more often than traditional procurements.

On the other hand, the Treasury Committee (2011) presents evidence that out-turn costs of construction and service provision are broadly similar between PFI and traditionally procured projects. Further, in terms of quality, the Royal Institute of Architects in the UK stated that the quality of the buildings delivered through PFI-type PPP was lower in many cases compared to traditionally procure ones (Treasury committee, 2011). This poor design has caused a number of issues, such as rising maintenance costs. Also, Boardman et al. (2005, cited in Hodge and Greve, 2007) presented evidence from the United States. According to them, five transportation, water-supply, and waste-disposal projects presented a series of 'imperfect' partnership projects with high complexity, high asset specificity, a lack of public sector contract management skills, and a tendency for governments to be unwilling to 'pull the plug' on projects once under way. As Hodge and Greve (2007) concluded, the VFM benefits of PPP are still subject to debate because of their considerable uncertainly. Moreover, it is difficult to obtain clear evidence on this in the absence of an accurate and uncontroversial public sector comparator (Hall 1998, cited in Hodge and Greve, 2007).

2.2 Solid Waste Management in Japan

2.2.1 Evolution of Solid Waste Management in Japan

In Japan, the evolution of SWM system has been fostered by government-driven policies from the beginning of last century. The municipalities have a responsibility to address the SWM issue by implementing collection, processing and disposal of municipal solid waste, including construction and operation of waste treatment facilities under the central government's financial and technical support and control. The main issue of SWM has changed coincidentally along with public demand.

Initially, the main challenge of SWM was how to deal with the increasing amount of solid waste, especially in urban areas. The main focus of public policy was simply to eliminate waste from inhabited areas in order to maintain public health by preventing epidemics (Shekdar, 2009; Tasaki, 2009; Akaishi, 2007). Thus, the collection system was developed alongside the expansion of urban areas. Thereby, massive amounts of waste were collected and disposed of, mainly by open dumping (Urabe and Inamura, 2006). Also, in this period, individual disposal processes using small incinerators were common for commercial waste. These small incinerators were often installed in business buildings in commercial areas (Ishii, 2006). However, the perspective of environmental preservation was not seriously considered when these disposal methodologies were applied. Therefore, these qualitative approaches against increasing solid waste caused significant pollution of the soil, groundwater and air around these facilities.

Gradually, the hazards of these uncontrolled disposal methods were recognised as solid waste research progressed. Public awareness of pollution from inadequate waste treatment facilities, such as open-dumping and small incinerators, would rapidly increase between late 1960s and 1970s (Urabe and Inamura, 2006; Yagi, 2006). Many large cities struggled to construct new facilities due to strong opposition from residents.

In 1971, a well-known opposition movement termed the ‘Waste War’ occurred in Tokyo (Ishii, 2006). Although it was originally an issue about conflict among the districts of Tokyo based on NIMBY (not in my backyard) resistance to a new incinerator construction site, the issue was caused by the representative SWM problems in society at that time. Japan was experiencing a period of rapid economic growth and people’s lifestyles were shifting towards a pattern of mass consumption. This change influenced both the waste generation rate and its composition, thus it made the SWM system more complex and costly.[2] Also, as a result of the expansion of urban areas, it became inevitable that there would be serious public opposition due to a lack of empty place that was far away from residential areas. However, in general, municipalities disregarded the importance of SMW in the organisation. Thus, they didn’t distribute enough financial and human resources to SWM departments, which lead to inadequate management that was unable to deal with these problems. Through a series of news reports related to the Waste War issue, the hazardous nature of waste treatment facilities was publicised throughout Japan as well as warnings about the shortage of disposal sites (Mizoiri, 2006).

[2] The shift of consumption pattern leads the generation of more various types of waste such as papers, plastics, metals (e.g. drink containers), bulk waste (e.g. electrical appliance).

Through these experiences, the general public developed a sense of fear about pollution from waste treatment facilities and inadequate management by public authorities. Thus, monitoring by civil society became much stronger and residents required higher levels of pollution control for waste treatment facilities rather than simply legal regulations.

Reflecting these concerns, in the 1970s, public policy shifted from a quantitative approach to a qualitative approach, which placed greater emphasis on environmental preservation (Tasaki, 2009). Alternative advanced technologies for waste treatment became more important in order for developments to be accepted by residents. Advanced technologies such as landfill and incineration were improved radically during this period. Also, various pollution control technologies were developed to prevent the emission of pollutant materials, such as dioxins, which were continuously being discovered.

At the same time, increasing public awareness also provided an opportunity for people to review their lifestyles. Although the inadequate management of SWM facilities by public authorities is a direct cause of pollution, the waste itself originally came from the people. Residents are therefore not only victims of waste pollution but are also polluters to some extent at least. The importance of eco-friendly consumption behaviour involving the 3R (Reduce, Reuse, Recycle) policy was becoming recognised little by little.

In the 1990s, the concept of sustainability was introduced into debates about SWM. Sustainable SWM policy aimed to realise the idea of sustainable SWM by the 3R policy in Japan (Ibid.). A similar waste hierarchy was also founded in the EU (Torii, 2011). [3] In 1992, 3R was formally stated as a national policy with the enforcement of amendments to the Waste Management and Public Cleansing Act. Moreover, in 2000, a basic law to promote a recycling-focused society, a so-called sound material-cycle society, was enacted in the context of a national drive towards sustainable development (Shekdar, 2009).

[3] Waste hierarchy: a concept proposes that waste should be managed by difference of the options represents the hierarchal structure. Thus, prevention, reuse and recycling are given the highest preference, while open burning and dumping are unacceptable (Reddy 2011).

In actual fact, behind the promotion of the 3R policy lay the difficulty of constructing new waste treatment facilities rather than the preservation of natural resource. Therefore, the main aim of central and local governments' efforts in promoting the 3R policy was to extend the life of existing landfill sites. To do that, municipalities had to introduce recycling facilities into SWM systems even if it is economically inefficient. For example, recycling of metal and plastic beverage containers costs appropriate 90 Yen (approximately US$1) per 45 litters (one bag) in Kitakyushu city, where they actually sell these materials (Iwasa, 2011).

As seen above, SWM has mainly dealt with environmental issues due to strong pressure from society over the last century in Japan. In order to address these issues, which have continuously appeared for several decades, municipalities have typically opted for ad-hoc technological solutions. Thus, the main focus of SWM development has been the technological upgrading of waste treatment facilities associated with pollution control technologies (Tasaki, 2009) and this technological upgrading has been supported by the central government in terms of technical and financial assistance, such as implementing public R&Ds and subsidies for construction of advanced waste treatment facilities. In this context, SWM infrastructures have a tendency to employ a higher level of technology in order to achieve greater environmental safety, and these requirements often involve a trade-off with economic efficiency (Eguchi, 1999).

As shown on Table 2.1, Japanese SWM system is different from oversears in terms of government initiative, main technology, procurement type from government and general business model pf PPP/PFI projects. In Japan, waste-to-energy is one of the main facility of Japanese SWM (because of lack of landfill site) and it consists of thousands equipment; it is highly complex product systems.

Table 2.1: Comparison between SWM in Japan and overseas

	Japan	Overseas
Government initiative	Government has strong leadership and ownership	Government leads to built SWM system consists of facilities owned by private companies
Main technology	Waste-to-energy facility is the main SWM facility	Landfill is the main SWM facility and less waste-to-energy facility
Procurement type from government	Performance order	Highly performance order
General business model of PPP/PFI project	Service purchase type (local government pay service purchase fee)	Independently profitable type (company collect usage fee from citizen)

As a consequence, Japanese SWM often suffers from serious cost inefficiency. In 2017, it cost JPY 15,500 (approximately US$140) per capita to treat waste on an annual basis (The Ministry of the Environment (MOE), 2011). The cost was significantly larger than that in with other countries (e.g. the average of those in high income countries is US$75 (Wilson et al., 2012)).

Furthermore, huge amounts of subsidies from the central government have been increasingly required by the municipalities, due to the rising number of treatment facilities requiring rebuilding. This has led to an increased fiscal burden on the central government (Takagi et al., 2013). Under this financial burden, in some cases, cutting subsidies was inevitable and it caused a delay in rebuilding projects (Ibid.). For instance, as Takagi notes, in 2013, the central government set a budget of JPY 35.4 billion (approximately US$350 million) for the subsidies, but it only covered 64% of the total amount required.

In summary, SWM in Japan has been developed in order to deal with environmental issues by technological upgrading under strong pressure from society over the course of the last century. As a consequence, advanced technologies for waste treatment and pollution control were significantly improved through technology direction and providing subsidies for the construction of advanced waste treatment facilities. However, the environment element of this solution caused serious cost inefficiency in the SWM system. The financial burden of SWM is one of the crucial issues for both central government and the municipalities.

2.2.2 Positive Role of PPP in SWM

As it shown on the SWM literature, Japanese SWM is facing serious cost inefficiency problems due to the need, under strong public pressure, to introduce advanced technologies to address the various environmental issues. The financial burden caused by the cost inefficiency is a crucial issue for both municipalities and the central government. Also, municipalities suffer from the requirement of higher technological knowledge and skills to manage and operate these cutting-edge technologies (Eguchi, 2011).

In this context, the need for PFI-type PPP in SWM projects is increasing in order to provide effective and cost saving SWM services as well as to access advanced technologies and advanced technologies and expertise of private companies (see Table 2.2 more specific characteristics of SWM PPP/PFI project compared with water/sewerage treatment). Eventually, the introduction of PPP procurement is expected to lead to greater sustainability by taking compatibility between environmental and economic aspects.

Table 2.2: Comparison between PPP/PFI project of SWM and water/sewerage treatment

	Japan	Overseas
Technology	Need advanced plant technology Highly complex product systems Private company has design, construction and O&M technology	Need plant and civil technology Less complex product systems
Procurement type from government	Performance order	Specification order
General business model of PPP/PFI project	Service purchase type (local government pay service purchase fee)	Independently profitable type (company collect usage fee from citizen)

In 1999, the first legal prescription of PFI arrangement in Japan, the so-called PFI promotion law, was enacted. The aim of this law was to promote the utilisation of private sector's finance, management and technological capabilities for the construction and operation of public facilities. SWM infrastructures such as waste treatment facilities and recycling facilities are recommended to use PFI-type PPP procurement in this PFI promotion law.

After establishing the PFI promotion law, PFI-type PPPs were introduced in many fields of public projects. A total of almost 740 projects have been procured by PFI arrangements and they have led to approximately JPY 800 billion saving compared to conventional procurement from 1999 to 2018 in Japan (Cabinet Office, 2019). In the SWM area, a large number of projects have already been procured by PFI arrangements and the great majority of them are for waste-to-energy plants. However, there is no comprehensive research focusing on the development of SWM innovation system through PPP/PFI procurements.

2.3 Procurement Process of PPP/PFI of Solid Waste Management

Using the representative case of the Narumi project, which was conducted by Nagoya city, this chapter provides the details of the procurement process of a PPP/PFI SWM project.

2.3.1 Basic Plan and Feasibility Study

The Narumi project was initiated by setting the clear goals on the part of Nagoya city. The Narumi waste-to-energy plant was planned in order to replace the previous facility, which closed due to difficulty in meeting revised regulation of dioxins. The basic plan was built under the concept of 'eco-friendly and resource recycling facilities,' which required higher levels of environmental sustainability such as energy recovery and material recycling, reduction of final disposal and preventing degradation of environmental quality. At the same time, Nagoya city was also promoting the introduction of PFI procurement for efficient implementation of public infrastructure. In Nagoya city, the 'financial reconstruction plan' and 'administrative and financial reform plan' were published in 2001. In these plans, the introduction of PFI and private participation were promoted for efficient infrastructure management under the limitation of governmental financial resources.

In this regard, the Narumi waste-to-energy plant was intended to be implemented as the first PFI procured project4, especially BTO scheme, under the Act on Promotion of Private Finance Initiative so-called PFI Act. In the feasibility study (Nagoya city Environment department, 2014), two main advantages of BTO option were highlighted through the Value for Money assessment. First, the introduction of PFI for the Narumi project would contribute to the equalisation of financial expenditure. Second, BTO will contribute whole life cost reduction compared to other procurement options. It was estimated that BTO would lead to 21% whole life cost reduction compared to conventional public procurement, while BOT would only reduce it by only 6% (Ibid.).

2.3.2 Bidding and Selection Process

In the PPP/PFI project, comprehensive evaluation was used for determining the preferred bidder. Unlike simple general competitive bidding which uses the lowest price approach, the evaluation method requires bidders to strike a balance between quality and bidding price.[5] In a comprehensive evaluation, the quality and price scores are converted into percentages in accordance with pre-set weightings and the combined score decides the preference bidder. Quality criteria such as technical merit and environmental characteristics were determined based on the subject matter of the project.

Figure 2.1 illustrates the process of the bidding procedure. At the bid announcement stage, municipality published the bidding documents, such as the output specification, the draft of contract and the award criteria. Then, pre-qualification and short-listing of interested parties was conducted based on the requirements shown in the bidding documents. After the submission, the

[4] At the stage, project team in Nagoya city was struggled with coordinating both internally and with external organisations. Since the Narumi WtE project was the first PFI procurement of Nagoya city, every relevant staff and congress member had to learn the complex method of PFI as well as members in the project team itself. Particularly, the number of relevant internal departments (approximately 10 departments) slowed the progress of planning process due to a flood of issues to be coordinated. Also, some local residents were concerned about implementation by private actors in terms of environmental stability for surrounding areas and they submitted a petition to confirm the appropriate monitoring by Nagoya city and the certain compensation if something is happened.

[5] Unlike the bidding process in the UK, the bidding method of this project basically does not allow negotiation after determination of the preferred bidder.

proposals were reviewed to ensure the satisfaction of output specification by Nagoya city. Finally, the Tender Evaluation Committee evaluated the proposals and determined a preferred bidder based on the award criteria.

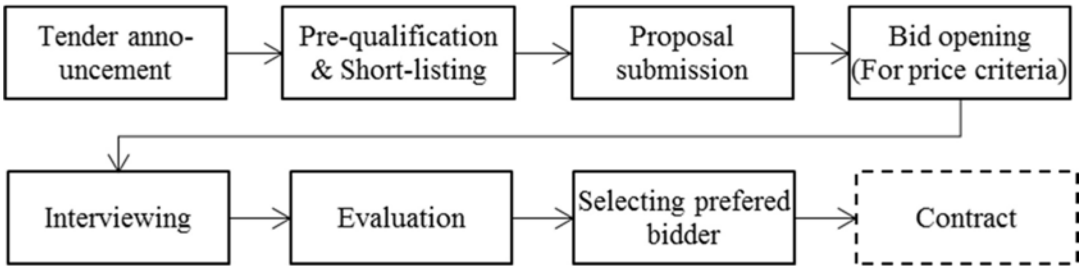

Figure 2.1: Process of the bidding procedure of waste-to-energy procurement

In the output specification, although it is a controversial issue about the degree of setting limitation for bidders, Nagoya city set minimum limitations and gave relative freedom to the bidders. According to the interview with Nagoya city, more room for design freedom in output specification would feel to encourage innovation in the project. Noticeably, the building layouts considering the effective management employed several new ideas for Nagoya city and contributed significantly to reducing the initial and operational cost. Meanwhile, the output specification included some requirements based on sophisticated planning in order to achieve the goals of Nagoya city. For example, this project required gasification and melting technology with the expectation of reducing final disposal waste by reflecting on the capacity limitation of landfill site in Nagoya city. Also, the recycling of generated slag and metals was required through the private actor's selling networks. Instead, the benefits from selling slag and metals as well as electricity are given to private actors.

The award criteria were composed of bidding price and non-price criteria and so made bidders engage in considerable effort to strike a balance between environmental and economic sustainability. As shown in table 2.1, the non-price criteria are composed in view of technological and environmental aspects as well as operation and managerial aspects. Essentially, environmental sustainability was highly weighted among these criteria. These award criteria would represent the public sector's expectation for private companies to achieve beyond the minimum requirement of output specification by the design innovation and effective management (Kato et al., 2007).

Table 2.3: Award criteria

Award criteria	Score
Non-price criteria	-
Project plan	12
Facility layout	12
Stability of the waste processing technology	22
Operation and maintenance plan	18
Environmental sustainability (e.g. Reduction of final disposal/ recycle of residues)	24
Business management plan	12
Bidding price	100
Total	200

Sources: Author's modification based on Nagoya city Environment department (2013)

Tenders' proposals were scored by the Tender Evaluation Committee based on the award criteria. The Tender Evaluation Committee comprised five experts from the Universities and the Development Bank of Japan (Nagoya city Environment Department, 2013). The Tender Evaluation Committee evaluated the Nippon Steel Corporation group's technological stability highly based on abundant similar project experiences and an integrated management plan associated with the collaboration of Nagoya city and local residents. Also, in terms of environmental aspects, the reduction of final disposal amounts due to the introduction of direct melting system in the plant and residues (molten slag and molten metal) recycling system based on marketing research were preferred.

Contractors were required to strictly keep to their commitments regarding technological and environmental performance through the whole project. Otherwise, penalties would be applied to contractors if they fail to deliver. For example, SPC would have to pay twice the transportation costs from the Narumi waste-to-energy plant's landfill site as a penalty if they could not recycle whole residues as promised (PFI/PPP promoting conference, 2010).

Chapter 3 Theoretical Background, Analytical Framework and Methodology

3.1 Introduction to the Chapter

This chapter begins with a description of theoretical streams underpinning this research, namely capability building of project-based firms through CoPS (Complex Product System) and mega-project, innovation in public service and innovation through public procurement. Focusing on the interrelationships among the different research streams and innovation, the last part of this chapter provides a brief description of the conceptual framework as well as the main research methods and data sources.

Section 2 presents theoretical background of these theoretical streams above. It is followed by analytical framework (section 3) and methodology of this research (section 4).

3.2 Theoretical Background

3.2.1 Evaluation of PPP/PFI Projects

Although PPP/PFI arrangements have been introduced in many social infrastructure projects in Japan and other countries, both researchers and governments have pointed out that the benefits of PPP/PFI are still subject to debate, and the evaluation of PPP/PFI has delivered contradictory evidence as to its real effectiveness (Hodge and Greve, 2007; HM Treasury, 2012; National Audit Office, 2018).

Hall (1998) suggested that the early PFI projects in the UK had achieved significant savings overall for road projects and two prison contracts that generated about 10% savings compared to publicly financed prisons. Similarly, the analysis of 29 business cases conducted by Arthur Anderson and Enterprise LSE (2000) identified 17% cost savings. Moreover, recent reports from Mott-Macdonald (2002) and the National Audit Office (2003) identify PPPs as delivering on time and on budget far more often than traditional procurements.

Conversely, the Treasury Committee (2011) presented evidence that out-turn costs of construction and service provision are broadly similar between PPP/PFI and traditionally procured projects. Further, in terms of quality, according to the Royal Institute of Architects in the UK, the quality of buildings delivered through PFI-type PPPs in many cases has been lower than traditionally procured ones (Treasury Committee, 2011). Such poor design has caused various issues, such as rising maintenance costs. Furthermore, Boardman et al. (2005) presented evidence from five projects including transportation, water-supply and waste-disposal in the United States and argued that these represent a series of 'imperfect' partnership projects with high complexity, high asset specificity, a lack of public sector contract management skills and a tendency for governments to be unwilling to 'pull the plug' on projects once they are underway. As Hodge and Greve (2007) concluded, the value-for-money (VFM) benefits of PPP/PFI are still subject to debate because of their considerable uncertainty. Moreover, it is difficult to obtain clear evidence of this in the absence of an accurate and uncontroversial public sector comparator (Hall 1998).

Studies on the effects of PPP/PFI have mainly focused on evaluations of projects and, as in the cases of those examples above, have determined that the effectiveness of PPP/PFI for providing public services depends on the project (Hodge and Greve, 2007; Treasury Committee, 2011; HM Treasury, 2012; National Audit Office, 2018).

3.2.2 Evolution of Organisational Capability under the PPP/PFI Arrangement

Brady et al. (2005a, 2005b) studied the evolution of construction firms' organisational capability through PPP/PFI arrangements. They introduced the concept of integrated solutions which capture the combinations of products and services that address a customer's unique requirements throughout the life cycle of development and design to systems integration, operations and decommissioning.

Brady et al. (2005a) mentioned that PPP/PFI projects potentially provide a supportive climate for a collaborative way of working between the suppliers of design, construction, operation and maintenance services, and this may lead private actors to exploit opportunities for innovation by creating a virtuous circle of learning between different stages of the capital goods innovation process. To foster system integration under the PPP/PFI arrangement, Brady et al. (2005a) also mentioned that construction firms need four capabilities: system integration, operational service, business consulting and financing capabilities.

However, Brady et al. (2005a) concluded that the accumulation of these capabilities to provide innovation in PPP/PFI projects is limited. This is because few PPP/PFI projects had been conducted at the time and the repeatability of PPP/PFI projects had not yet emerged during the period under study, according to the research by Gann and Salter (2000). They also concluded that in the construction industry, the process of shifting towards integrated solutions is not easy and takes time. Thus, long-term research is needed to capture the capability-building towards more service-enhanced and integrated solutions in construction firms.

3.2.3 Organisational Capabilities of Construction firm

Several studies have been conducted in the last 20 years on the capabilities of construction firms as project-based companies (e.g. Davies and Brady, 2000; Gann and Salter, 2000; Brady and Davies, 2004; Davies and Brady, 2016; Davies et al., 2016; Zerjav et al., 2018).

Davies and Brady (2000) established the concept of project capability in the supplier's complex product systems (CoPS) model by developing the theory of Chandler's (1990) organisational capabilities framework. Chandler (1990) argues that firms compete for market share by improving their strategic and functional capabilities. Strategic capabilities are a firm's ability to move into growing markets more quickly, and out of declining ones more rapidly and effectively, than its competitors (by top management). Functional capabilities are to improve a firm's R&D, product design, production, distribution, purchasing, finance and general management (by middle managers). Also, Chandler's framework explains how companies grow by: (1) obtaining economies of scale and scope in production, (2) creating a marketing and distribution network so that the volume of sales matches the volume of production, (3) establishing a management structure to co-ordinate functional activities and to strategically plan and allocate resources for future production. Also, Chandler (1990) showed learning curve emphasised first movers are able to move down the learning curve: gain competitive advantage.

Davies and Brady (2000) pointed out the need of a modification in Chandler's framework is required due to differences between the natures of production in CoPS compared with high-volume production. (1) While strategic and functional effectiveness is important in CoPS, scale and scope advantages are difficult to realise because production is limited to unit or small, tailored batches, (2) the order functional activities in project-based production is the reverse of mass production (marketing first, production later), (3) Particular forms of organisation are appropriate for each system of production.

Thus far, Davies and Brady (2000) introduced the concept of 'project capabilities' to (1) the preparation of the bid (including requirements gathering after receiving an invitation to tender from a customer; conceptual design specifying components in the proposed system; estimation of costs etc.) and (2) the execution of the project after winning the bid (including integrating organisational functions; purchasing resources inside and outside the firm; managing and reallocating resources through the project life cycle using milestones and deadlines; etc.). (See Figure 3.1)

Moreover, Davies and Brady (2000) proposed that organisational learning cycle which by the process of building capabilities and learning takes place in four overlapping stages. Although there is less scope for routinised learning in CoPS because projects are inherently one-off or unique, there are opportunities for learning because firms undertake similar categories of projects which involve repeated cycles of activity. (See Figure 3.2)

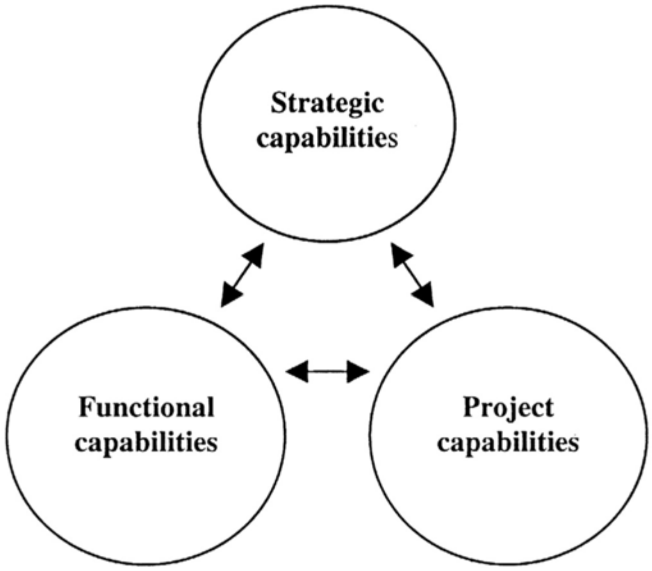

Figure. 3.1: Organisational capabilities in CoPS

Source: Davies and Brady (2000)

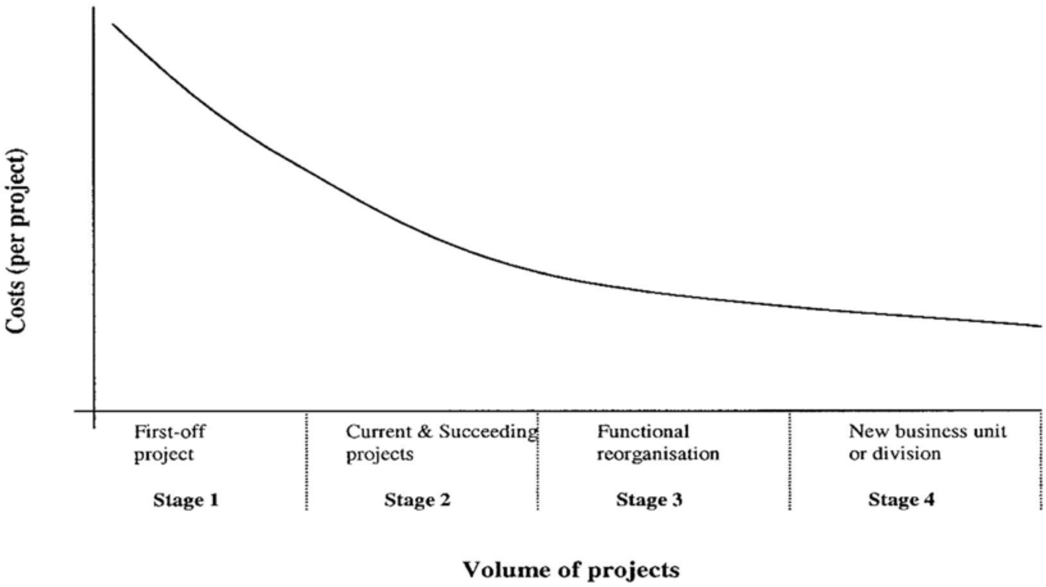

Figure. 3.2: Organisational learning cycle

Source: Davies and Brady (2000)

Bell (2009) distinguished between two kinds of innovation capability (i.e., technological capability and organisational capability), pointing out that a production's organisational aspects (i.e., organisational capital) are a component of its technological capabilities. Organisational capital encompasses not only the internal organisational structures and procedures of firms but also the external links and relationships they may have with other firms and related organisations.

Moreover, Bell and Figueiredo (2012) outlined the aspects of the two dimensions of innovative capability: the technological is centred on human resources, skills and knowledge bases, and the organisational is centred on forms of organisational specialisation/differentiation, integration/co-ordination and meta-level 'orchestration'.

According to Dutrenit (2000), the relative importance of the different kinds of organisational issues seems to vary with the different levels of innovative activity. His theoretical model of innovation capability accumulation is illustrated in Figure 3.3.. Initially, as firms move through the lower levels of capability building to support more systematic forms of incremental innovation, the main emphasis is on creating the key 'technological' elements of capability, which move 'vertically' upwards in Figure 3.3.

At the initial stage, the associated organisational issues are about organisational specialisation and differentiation. However, as firms reach more advanced levels of innovative activity, they move through, as Dutrenit suggested, a 'transition phase', during which they not only continue moving 'upwards' to achieve more advanced and then globally leading levels of capability in technological terms, but also have to move 'horizontally' to address the increasingly important issues about building organisational capabilities for integration and co-ordination.

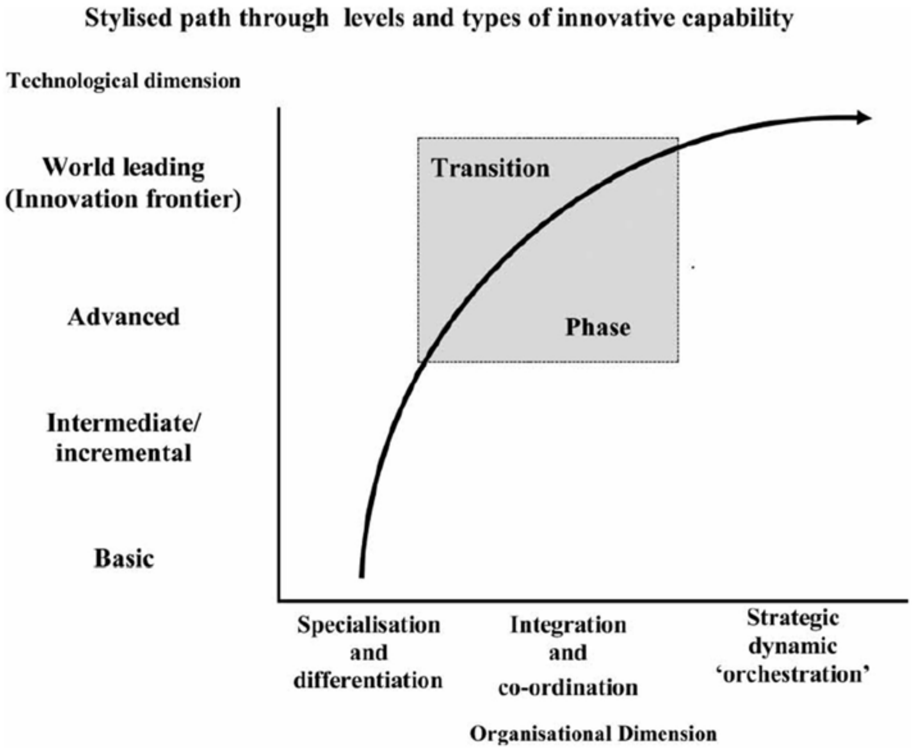

Figure 3.3: Innovation capability accumulation: changing emphasis on 'technological' and 'organisational' dimensions

Source: Adapted from Dutrenit (2000) cited in Bell and Figueiredo (2012)

Gann and Salter (2000), on the other hand, studied a framework for better conceptual understanding and new management practices to link project and business processes. It is explaining that dynamics of project-based firms and how they can improve performance across portfolios of projects also pointed out that even there are the rich stream of theorising on the nature of the firm, little effort has been made to account for the particular project-based nature of construction firms, or to apply resource-based theories to these types of firms. Figure 3.4 illustrates the project-based firm and technical resource flows in-house support and external research and technical support services bought-in by firms. The model shows that project-based firms need to manage both project and business processes. The resources of the firm are embedded at both the project and the firm level. It is the integration of these two sets of resources that enables the firm to be competitive. In this study of organisational capabilities of previous construction companies (Gann and Salter, 2000), collaboration with external companies through the project was considered only as suppliers and technical partners.

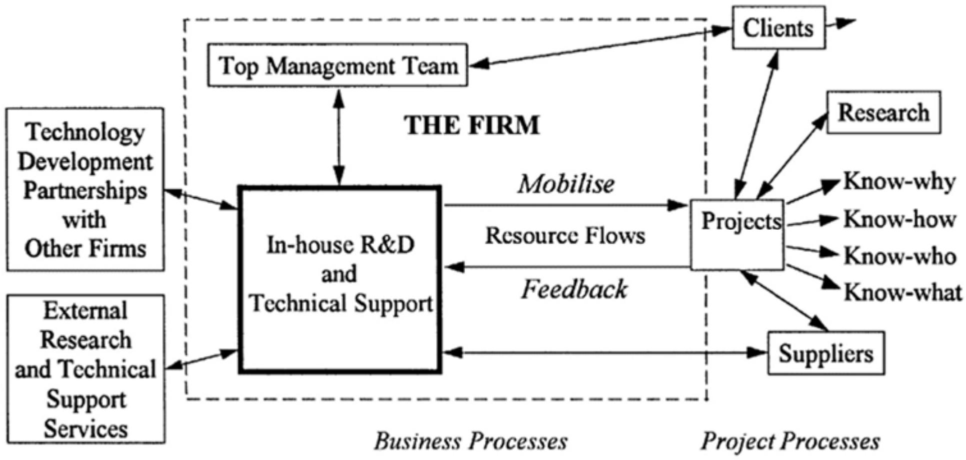

Figure 3.4: The project-based firm and technical resource flows

Source: Gann and Salter (2000)

In the other paper, Davies and Brady (2016) defined project capability, which is distinguished from the dynamic capability of a project-based organisation, as follows: 'The concept refers to the distinctive managerial knowledge, experience and skills, which are located within a single organisation (a firm) and which are required to establish, coordinate and execute projects'. However, most studies have focused on project-based analyses (e.g. London Heathrow Terminal 5 project [Davies and Brady, 2016; Davies et al., 2016] and the London Olympics [Grabher and Thiel, 2015; Worsnop et al., 2016]). Therefore, there is still little understanding of the long-term dynamics of the evolution of project-based firms' capabilities. Also, this research is focused on the only single companies. Thus, there is lack of considering collaboration with other firms. There are various ways for a project-based firm to accumulate capabilities, such as through project-to-project learning or within groups of firms in the business ecosystem.

Grabher and Thiel (2015) analysed the 2012 London Olympics to present how project capabilities are mobilised in complex projects. They found that the Olympic Delivery Authority had to mobilise specialised knowledge and project capabilities embedded in a network of firms and individual project professionals that brought their experience from previous projects. The present study underlines the importance of the wider ecosystem of project capabilities distributed among a community of firms and professionals in the sector. In this dissertation, we highlight bringing project capabilities from outside the firm as collaborative capability to examine the capability for open innovation more clearly.

From the point of view of service innovation in firms, a firm's technological capability often influences the innovation in its service. As Djellal et al. (2013) mentioned, innovation in public services has long been preoccupied with the introduction of new technologies, and especially with the introduction of new IT technologies, and the changes in business organisation associated with the use of these technologies.

3.2.4 Public Procurement and Innovation

In the public service field, PPP/PFI is recognised as a key element of demand-oriented innovation policy (Brady et al., 2005; Edler and Georghiou, 2007; National Audit Office, 2007). However, as shown above, owing to the considerable uncertainty of each project, the benefits of PPP/PFI are subject to debate (Hodge and Greve, 2007; National Audit Office, 2018), as is the role of public procurement in fostering public service innovation (Djellala et al., 2013).

Public procurement's effect of stimulating private sector innovation has been debated particularly in the context of so-called 'demand-side' innovation policies (Uyarra et al. 2014). By enlarging the market for certain goods and services, public procurement can counteract market and systemic failures that hinder innovation, thus ensuring sufficient critical mass to encourage R&D investment. The use of public procurement has been associated with the emergence of so-called 'lead markets' (see i.e., Geroski, 1990; Edler and Georghiou, 2007).

However, there is an obstacle to foster innovation, for example, because the flexibility for interaction during a procurement process is regulated in all countries that have signed on to the Government Procurement Agreement in the WTO and EU Directives. Uyarra et al. (2014) sought to understand how barriers related to processes, competence, procedures and relationships in public procurement influence suppliers' ability to innovate and reap the benefits of innovation. They found that the main barriers reported by suppliers were lack of interaction with procuring organisations, use of over-specified tenders as opposed to outcome-based specifications, low competence of procurers and poor risk management during the procurement process. Despite this body of work, few studies have investigated thoroughly the specific conditions or mechanisms within public procurement that actually lead to or hinder innovation (Geroski, 1990).

3.2.5 Collaboration with Competitors

In the field of PPP/PFI arrangement, collaboration with other companies is one of the key factors for capability development, and sometimes construction firms face situations that demand them to collaborate with competitors.

Research on collaboration with competitors, the so-called co-opetition (Gnyawali and Park, 2011), has increased owing to its practical significance (Walley, 2007). Co-opetition is actively researched to study technological development in high technology contexts (Gnyawali and Park, 2011) because of several challenges, such as shrinking product life cycles, the need for heavy investments in research and development, the convergence of multiple technologies and the importance of technological standards (Gnyawali and Park, 2009).

However, despite its increased importance, it has not been adequately examined, especially in the field of project-based organisations such as construction firms. Because competing firms possess relevant resources and face similar pressures, collaboration with competitors enables firms to acquire and create new technological knowledge and use it to pursue innovations (Ritala et al., 2009). In studying business networks, the relationships between competitors have not been analysed to the same extent as vertical relationships (Bengtsson and Kock, 1999). Cooperative relationships between vertical actors e.g.– buyers and sellers, for instance – are easier to grasp as they are built on the distribution of activities and resources among actors in a supply chain. Horizontal relationships, on the other hand, are usually more informal and invisible. In addition, vertical relationships often contain economic exchange, which seldom is the case in horizontal relationships, which are built mainly on information and social exchanges. Moreover, due to the difficulty of conflict management and the lack of knowledge sharing due to the awareness of rivalry as a barrier, horizontal integration is considered to be difficult to work effectively.

Through the lens of organisational capability, Gnyawali and Park (2011) stated the importance of firm capability to effectively manage co-opetition: it would help generate higher common benefits and appropriate a greater share of such benefits. Also, a firm with the mindset and experience relevant for co-opetition may be able to handle conflicts, create greater value and appropriate bigger private benefits.

3.3 Analytical Framework

In this study, we analysed construction firms' capability accumulation in terms of open and service innovation after undertaking long-term PPP/PFI projects. Based on previous research on organisational capability of construction firm under the PPP/PFI arrangements, we focused on the three capabilities of a construction firm – project capability, collaborative capability and technological capability – under the firms' strategy and how the evolution of organisational capability influences firm performance. The analytical framework is illustrated in Figure 3.5.

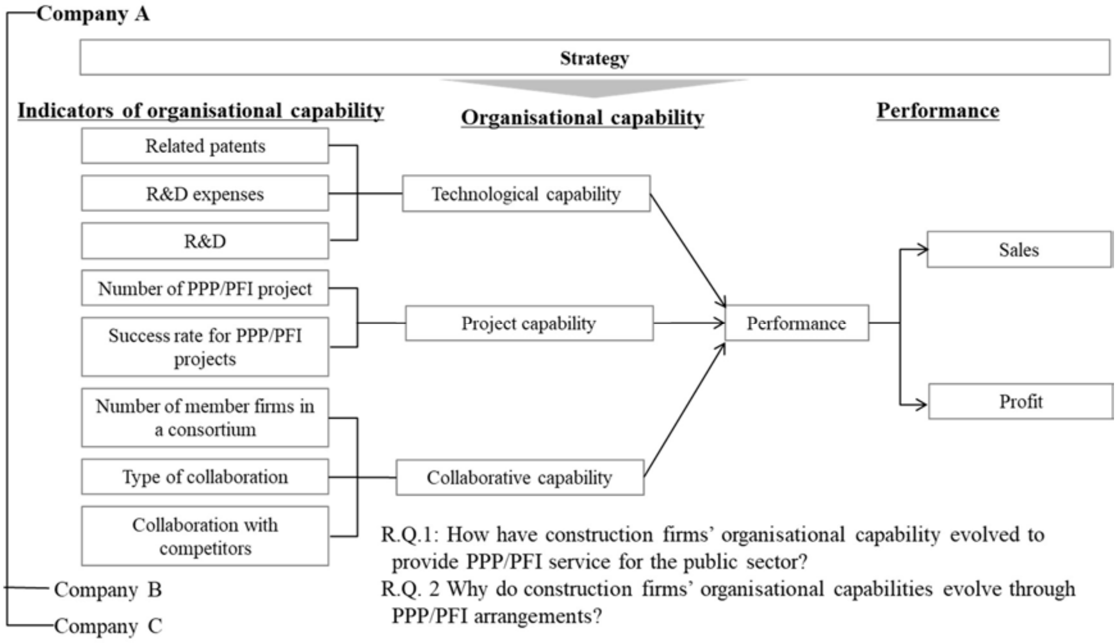

Figure 3.5: Analytical framework

We selected waste-to-energy PPP/PFI projects for analysis. The structural and functional features of an innovation system can serve as an effective conceptual framework to interpret waste-to-energy PPP/PFI projects in Japan. Three reasons underpin the adoption of this system.

First, an SWM system is complex and embraces diverse concerned actors from the public and private sectors as well as non-governmental organisations and the general population. These actors behave differently based on their own aims and rules for participation in the SWM system.

Second, the penetration of a PPP arrangement into an SWM system changes the institutional relationships and interactive patterns between public and private actors. The institutional change towards a PPP arrangement causes a change in the innovation process of a public-driven SWM.

Third, the increasing concern for sustainability in an SWM system poses the issue of a trade-off between environmental and economic sustainability, particularly under the PPP arrangement. In general, at least in Japanese SWM systems, public authorities are primarily concerned about environmental protection, while private participants are concerned about economic stability.

This contestable nature of sustainability can undermine the efficient management of PPP-led SWM systems.

Evidently, PPP-led SWM systems are not only concerned with cost-saving issues – the typical aim of PPP arrangement – but also with the effective networking of various public and private actors in terms of the compatibility of economic and environmental sustainability. In turn, the effective networking of actors in a PPP context directly corresponds to the concept of an innovation system, such as interactions through certain types of institutional arrangements. That is, by drawing on the concept of an innovation system, the innovation process in a PPP-led SWM system can be interpreted in terms of compatibility.

Herein, a specific institutional feature of PPP-led SWM should also be considered. PPP-led SWM is a project-based temporal (not permanent) system. In general, highly specialised private actors come together to secure the efficiency of each task (Gann and Salter, 2000). While a PPP project can harness the high-level division of labour from both the public and private sides, there are some potential risks in a project-based innovation system. One is the risk of low interaction among actors with different expertise due to the partitioning of specialisation. The other is the discontinuous nature across projects, which results in fragmented knowledge sharing due to broken learning and feedback loops (Gann and Salter, 2000).

3.4 Methodology

3.4.1 Research Method

Since theory on how and why construction firms' organisational capability evolved to provide PPP/PFI projects is limited, we relied on inductive theory building using multiple cases (Eisenhardt, 1989a). Multiple cases are likely to yield a more generalisable, robust, parsimonious theory than single cases (Eisenhardt and Graebner, 2007). Our embedded design, which used several units of analysis – e.g. firm performance, collaboration with companies and so on – improved the likelihood of developing a rich and accurate theory (Yin, 2013).

We focused on plant engineering companies that conduct waste management PPP/PFI projects. Waste management is one of the active areas for PPP/PFI projects, with 1,437 projects procured in the last two decades in various fields of public service in Japan (e.g. schools, sports facilities, hospitals and waste management facilities). In the field of waste management, in particular, PPP/PFI procurement has been actively introduced, and 205 projects have already been delivered (based on the PFI information[6]).

3.4.2 Overview of Focal Firms

Out of the six main plant engineering companies that conduct waste management PPP/PFI projects (Table 3.1), three were selected: Hitachizosen, Ebara and Takuma. Relatively small companies compared to the other three, their sales rely on SWM-related business, which mainly consists of waste-to-energy PPP/PFI projects. Since they have been actively participating in SWM PPP/PFI projects for the last two decades, analysing them was expected to be fruitful in capturing how their evolving organisational capability, due to their participation PPP/PFI projects, influenced their performance.

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[6] PFI information: http://www.pfinet.jp/

Table 3.1: Overview of the focal firms

Firm	Sales[7] (Total) (Million Yen)	Sales[8] (SWM-related business segment) (Million Yen)	Number of SWM PPP/PFI projects[9]	Case study
Hitachizosen	408,592	270,278	45	Selected
Ebara	523,727	67,547	38	Selected
Takuma	146,726	120,770	35	Selected
JFE	3,227,285	NA	24	-
Mitsubishi Heavy Industries	3,699,946	NA	21	-
Nippon Steel	4,829,272	NA	19	-

3.4.3 Data Collection

3.4.3.1 Company Data

To evaluate the evolution of the focal companies' performance through PPP/PFI project participation, company-wide data and business segment data were collected. The company data was collected by Factiva[10] provided by DOW JONES. Table 3.2 shows the conditions for extracting company data for analysis.

Table 3.2: Collected company data

- Company-wide data and business segment data between 2002 and 2020 (the data collection period depended on data availability)
Company-wide data
- Sales
- Profit
- R&D expenses
- R&D strategy
Business segment data

[7] Based on the securities report of 2020
[8] Based on the securities report of 2020
[9] Based on the number of bid participation for SWM PPP/PFI projects contracted between 1 January 2002 and 20 July 2021
[10] Factiva: https://www.dowjones.com/professional/factiva/

-	Products of SWM-related business segment
-	Sales
-	Profit
-	R&D expenses
-	R&D strategy

3.4.3.2 Patent Data

To understand the accumulation of technological capability, the focal companies' patent data – collected from J-PlatPat, the patent database of Japan patent office – was analysed. Table 3.3 shows the conditions for extracting patent data for analysis.

We also investigated the firms' corporate strategy and R&D strategy based on their annual reports from 2000 to 2017, their medium- and long-term plans, patents, publications and internal technical reports.

Table 3.3: Conditions for extracting patent data to be analysed

-	Patent registered in Japan
-	Patent applied by the focal companies
-	Patent applied between 1 January 1996 and 31 December 2020
-	Extract the following IPC code (FI code) patent information related to basic waste-to-energy technologies: B09B: waste treatment F23G: incinerator technology F23J: ash/residue treatment technology

3.4.3.3 Project Data

To analyse the change in the focal companies' success rate of PPP/PFI project bids, an original PPP/PFI project bidding information database was built based on the data collected by PFI information[11] provided by PFI net. Table 3.4 shows the conditions for extracting PPP/PFI project data for analysis.

As part of the quantitative analysis, the results of 1,437 bids for PPP/PFI projects by the focal firms were analysed. The bidding information was collected from tendering documents in the PPP/PFI project database presented by PFI Information [12] and Japan PFI/PPP Association [13]. The bidding information included the contract-based project details, the list of member companies and their roles, the results of evaluations by a selection committee and a summary of the proposals.

Table 3.4: Conditions for extracting PPP/PFI project data for analysis

- PPP/PFI projects procured in Japan
- PPP/PFI projects the focal companies participated in
- PPP/PFI projects contracted between 1 January 2002 and 20 July 2021

3.4.3.4 Interview

For a more detailed analysis, ten people from the PPP/PFI sector were interviewed, including people from construction firms (plant engineering and civil works) and waste management companies, municipalities and waste management associations. The questions for the interviewees are presented in Table 3.5., and the interviewee list is shown in Table 3.6.

We conducted a detailed interview of members of plant engineering company A, that lasted four hours, focusing on issues such as company strategy in PPP/PFI projects, the proposal process, the execution of PPP/PFI and organisational changes over the last two decades.

Table 3.5: List of interviewees

No.	Company	Date of the interview
1	Plant engineering company A	27th/June/2017, 23rd/May/2018
2	Plant engineering company A	27th/June/2017, 23rd/May/2018

[11] PFI information: http://www.pfinet.jp/
[12] Website of PFI Information: “http://www.pfinet.jp/”
[13] Website of Japan PFI/PPP Association: “http://www.pfikyokai.or.jp/index.html”

3	Plant engineering company B	11th /Aug/2014
4	Civil engineering company C	16th /Oct/2017
5	Waste management company	4th /Dec/2017
6	SPV of waste-to-energy PFI project	12th /Aug/2014
7	Municipality D	4th /Oct/ 2017
8	Municipality E	1st /Aug/2014
9	Waste management association	10th/ Mar/2017, 22nd / Nov/ 2017
10	Civil consulting company F	28th /Sep/ 2018

Table 3.6: List of interview questions

- Reasons for introducing PPP/PFI projects
- Advantages and difficulties of PPP/PFI projects
- Tendering and selection process of PPP/PFI projects
- Organisational changes to adapt PPP/PFI projects
- Collaboration with other companies for PPP/PFI projects
- Risks of PPP/PFI projects
- Accumulation of capability of firms and municipalities through PPP/PFI
- Technological change through PPP/PFI projects

3.4.4 Data Analysis

The quantitative and qualitative analyses were conducted based on Eisenhardt's approach (Martin and Eisenhard, 2010; Tsuboyama, 2021).

First, the three firms' cases were analysed through the lens of the accumulation of three organisational capabilities: technological capability, project capability and collaborative capability as well as their performance. Several indicators (Table 3.7) were introduced to analyse the evolution of these capabilities. (Section 4.2–4.4)

Table 3.7: Indicators for measuring organisational capabilities

Categories	Indicators
Performance	- Sales - Profit
Technological capability	- Patent registration

	- R&D expenses - R&D strategy
Project capability	- Number of conducted PPP/PFI projects - Shift of success rate of PPP/PFI bids
Collaborative capability	- Number of member firms in a consortium - Collaboration with competitors - Change in role of each member company

Second, to answer the research questions below (Section 4.5), the capability developments and the reasons for the occurrence of these developments were compared:

R.Q.1: How have construction firms' organisational capability evolved to provide PPP/PFI services for the public sector?
R.Q.2: Why do construction firms' organisational capabilities evolve through PPP/PFI arrangements under their strategy?

Chapter 4 Dynamics of Construction Firms' Organisational Capability

4.1 Introduction to the Chapter

This chapter describes the in-depth case study of the three Japanese construction companies and shows the dynamics of project-based firms' capability accumulation through a PPP/PFI arrangement. The study identified a model of capability development for construction firms, a model that can be considered ideal for understanding the long-term capability accumulation of project-based firms, especially regarding providing services that meet the public's needs.

This chapter illustrates the case study of Hitachizosen (Section 4.1), Ebara (Section 4.2) and Takuma (Section 4.3), which were analysed from five points of view: sales and profit by SWM-related business, transition of patent registration and R&D strategy, success rate of PPP/PFI project bids, collaboration with other companies within a project, and shift of the role of each member. This is followed by a discussion (Section 4.5) and chapter summary (Section 4.6).

4.2 Hitachizosen

4.2.1 Case Description

In the last two decades, over 1,400 PPP/PFI projects have been procured in various fields of public service in Japan (e.g. schools, sports facilities, hospitals, and waste management facilities). In the field of waste management, in particular, PPP/PFI procurement has been actively introduced, with 205 projects already delivered.

Hitachizosen is one of the most experienced companies in the field of waste management PPP/PFI projects. Based on the tendering information, between 1 January 2002 and 20 July 2021, it participated in 56 bids for PPP/PFI projects and succeeded in procuring 30 of them.

Hitachizosen’s main business is environment and plant (mainly a waste-to-energy plant[14]), which accounts for 66% of their total sales[15]. In the last 10 years, their environment and business plant segment sales increased 1.6 times, from 166 billion yen in 2011 to 270 billion yen in 2020, resulting in rapid growth in their total sales: from 303 billion yen in 2011 to 408 billion yen in 2020.

Hitachizosen was established in 1881 as a shipbuilding company. British E.H. Hunter founded Osaka Iron Works (individual management) on the banks of the Ajigawa River in Osaka. In 1882, the first new ship "Hatsumaru" (wooden 14GT) was built, and in 1890, Japan's first steel ship, the cargo-passenger ship "Kuma Kawamaru" for Osaka commercial ships was built.

Although Hitachizosen was founded in shipbuilding, the shipbuilding business was transferred to Universal Shipbuilding in 2002, and now the main focus is on environments and plants such as waste incineration, recycling facilities, and water / sludge treatment facilities. Currently, Hitachizosen is demonstrating his technological capabilities in business areas such as green energy, social infrastructure development, and disaster prevention systems.

Hitachizosen's current main products are the design and manufacture of waste incineration power generation facilities, seawater desalination plants, water and sewage / sludge recycling plants, marine engines, presses, process equipment, precision machinery, bridges, water gates, disaster prevention related equipment.

Hitachizosen's total sales was 408,592 million JPY and sales of SWM-related business segment was 270,278 million JPY. 66% of total sales are from SWM-related business segment.

Hitachizosen has shared their open financial data concerning sales and profit by SWM-related business segment. Table 4.1 shows the segment information.

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[14] Waste-to-energy is a technology for solid waste treatment and power generation by incineration or fermentation of waste.

[15] Hitachizosen’s annual sales total JPY408,592 million, and the sales of its environment and plant total JPY 270,278 million (as of 2020).

Table 4.1: Products of Hitachizosen's SWM-related business segment

Name of business segment	Products
Environment and plant	Waste incineration/recycling facility, water/sludge treatment facility, energy recovery system (garbage power generation equipment, for instance), biomass utilisation system, seawater desalination plant

4.2.2 Sales and Profit by SWM-related Business Segment

Figure 4.1 shows the sales and profit results of Hitachizosen's related business segment between 2002 and 2020. Over the last decade, after they started to participate in PPP/PFI projects, Hitachizosen's sales have grown significantly. Between 2006 and 2020, the compound annual growth rate (CAGR) of segment sales was 5.5%, and the segment profit – especially after 2005 (except in 2017 and 2018) – increased.

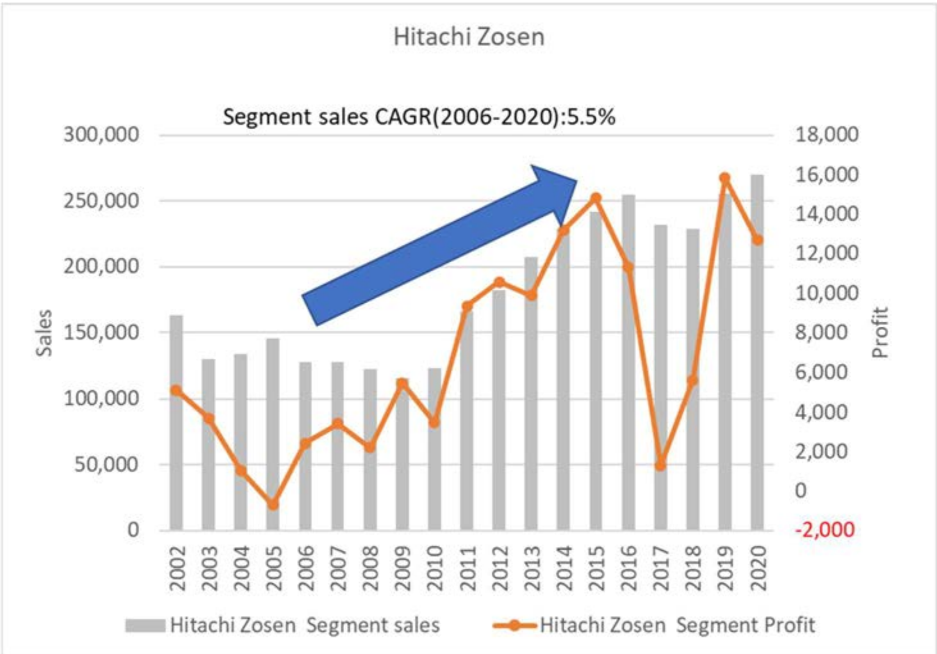

Figure 4.1: Sales and profit by SWM-related business segment (SWM-related business segment: Environment and plant department)

4.2.3 Transition of Patent Registration and R&D Strategy

To understand the accumulation of technological capability, the results of the analysis of Hitachizosen’s patent data are shown in Figure 4.2. Table 4.2 shows the conditions for extracting patent data for analysis.

Table 4.2: Conditions for extracting patent for analysis

- Patent registered in Japan - Patent applied by Hitachizosen - Patent applied between 1 January 1996 and 31 December 2020 - Extract the following IPC code (FI code) patent information related to basic waste-to-energy technologies: B09B: waste treatment F23G: incinerator technology F23J: ash/residue treatment technology

Figure 4.2 shows the trend in the number of patents related waste-to-energy technologies, based on the four-digit IPC code (FI code). The analysis shows a shift in Hitachizosen's patent concentration over the last 25 years. The cumulative total of number of patent registration during last 25 years is 309.

First, a large number of related patents were applied before 2002, when Hitachizosen started participating in PPP/PFI projects. They actively developed a recycling technology in the period from 1996 to 2001 in order to capture business opportunities to the significant institutional change towards recycling-oriented society under the Basic Act on Establishing a Sound Material-Cycle Society founded in 2000.

The number of patents which related to the solid waste treatment technology then significantly decreased after 2002. This implies that participation and execution of PPP/PFI projects is not directly related to number of patents registered. Hitachizosen representative mentioned that they tend to use robust technology for PPP/PFI projects in order to lessen risks of operation and maintenance. For PPP/PFI projects, Hitachizosen has to take on the risk for 15–

20 years of operation and maintenance of waste-to-energy facilities, based on the long-term PPP/PFI contract.

They therefore do not have a strong motivation to introduce leading-edge technology, which may have led to the reduction in the number of patent registrations by Hitachizosen, especially those related to waste management technology (especially equipment related technologies). These R&D trends are also confirmed with what is stated in their R&D strategy in their securities reports.

Furthermore, technologies contributing to operations efficiency, such as technologies for power generation efficiency, for prolonging the life of components and for automatic clearing system, are being developed. Hitachizosen's recent publications such as academic papers, internal technical reports and the financial annual report indicate that they have recently invested more in R&D for operational technologies and information technologies. For example, they were building a remote monitoring system centre in their head office in 2011 to collect operating information from each plant in their PPP/PFI projects to ensure stability and efficiency in sharing information and resources. They will further expand the remote monitoring system centre in 2018 to adapt to the increasing demand of the operating system. In addition, they are improving their automated operations system in order to lessen the burden of operations by codifying tacit operating knowledge.

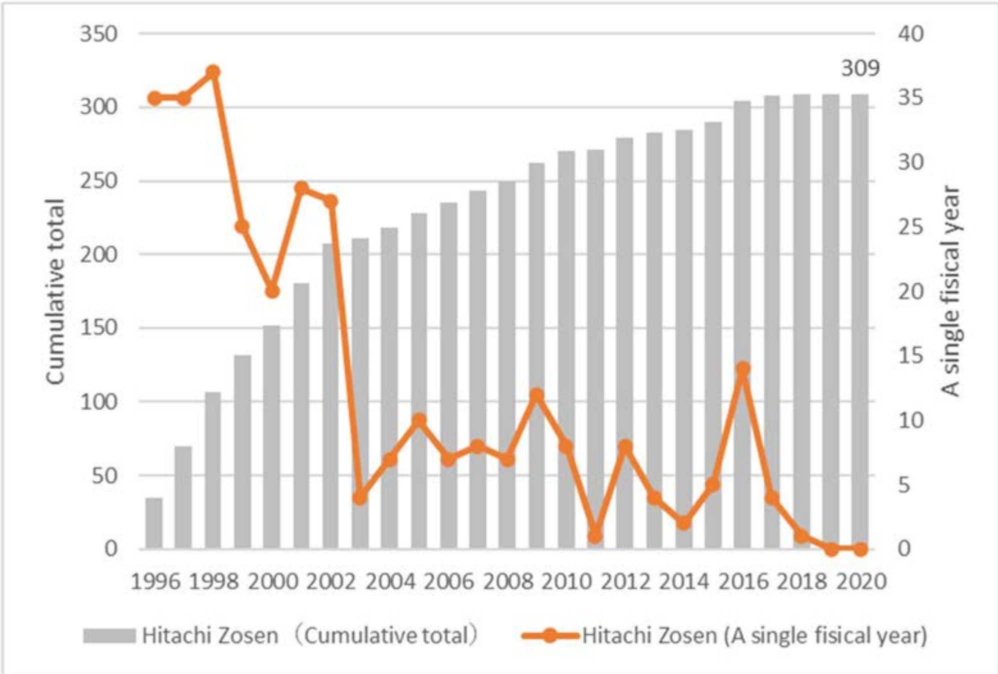

Figure 4.2: Number of patent registration (Hitachizosen)
(Solid waste treatment related technologies)

Figure 4.3 shows Hitachizosen's research and development expenses by SWM-related business segment between 2003 and 2020. Although it is difficult to compare Hitacihzosen's research and development expenses before and after they started participating in PPP/PFI projects in 2002 due to data limitations, Figure 4.3 shows that Hitachizosen spent their resources on their R&D activities and accumulated technological capabilities to a certain extent even after they started doing PPP/PFI projects.

(Unit: Million Yen)

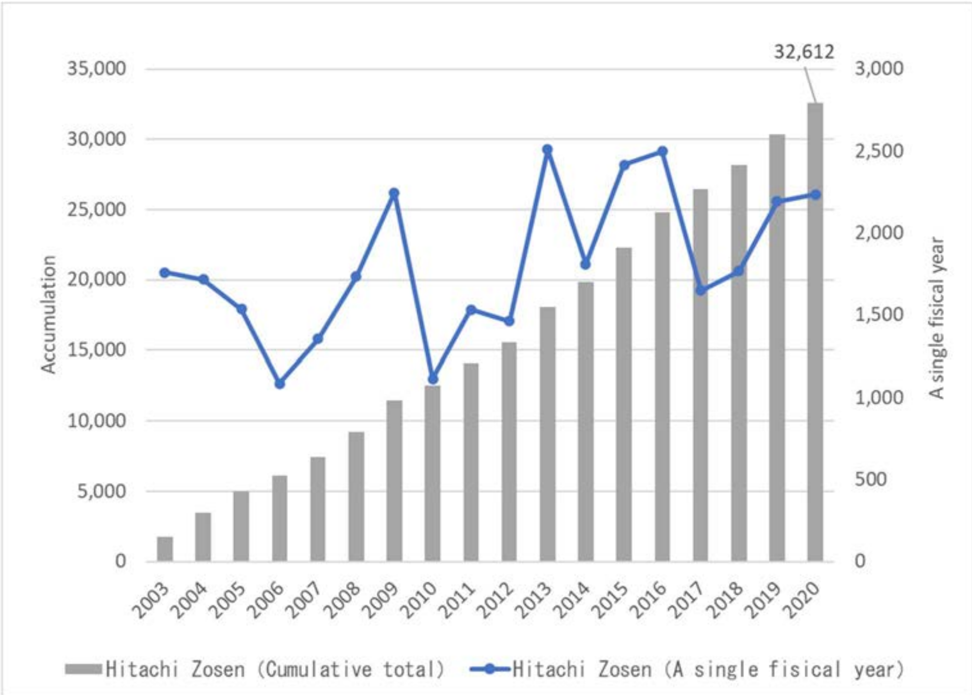

Figure 4.3: Research and development expenses by SWM-related business segment (Hitachizosen)

(SWM-related business segment: Environment and plant department)

4.2.4 Shift in Success Rate of PPP/PFI Project Bids

Owing to their 20-year PPP/PFI project experience, Hitachizosen have accumulated considerable project capability. To analyse the change in Hitachizosen's success rate of PPP/PFI project bids, an original PPP/PFI project bidding information database was built based on the data collected by PFI information[16] provided by PFI net. Table 4.3 shows the conditions for extracting PPP/PFI project data for analysis.

Table 4.3: Conditions for extracting PPP/PFI project data for analysis

- PPP/PFI projects procured in Japan
- PPP/PFI projects Hitachizosen participated in
- PPP/PFI projects contracted between 1 January 2002 and 20 July 2021

[16] PFI information: http://www.pfinet.jp/

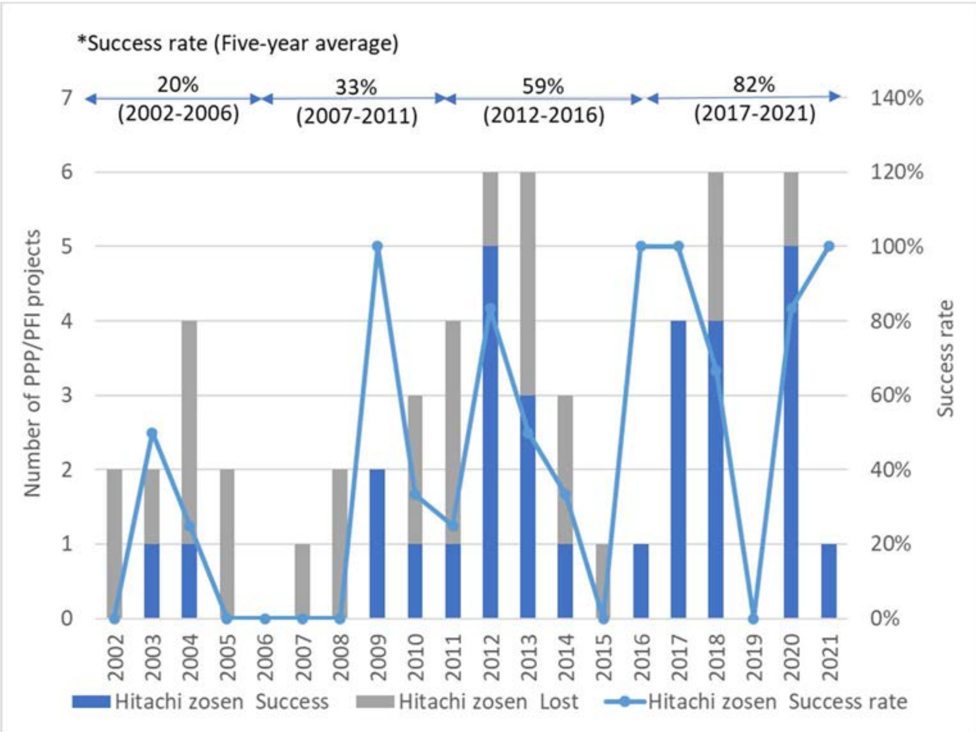

Figure 4.4: Shift in success rate of PPP/PFI projects based on the results of tendering (Hitachizosen)

Source: Own elaboration based on original PPP/PFI project database

From 2002 to July 2021, Hitachizosen participated in bids for 56 PPP/PFI projects, succeeding in procuring 30 of them (average success rate: 54%). The success rate, as shown in Figure 4.4, has been growing since 2002. During the initial stage, Phase 1 (2002–2006), Hitachizosen struggled to win bids for PPP/PFI projects, winning only two projects out of 10 bids in five years. They participated in the bidding for various projects, not only for waste management but also for water treatment, parking lots and container terminals. Most of their PPP participation projects were of the PFI, which required business investment, and they had to compete with not only engineering companies but also various investor-led consortiums.

In 2009, during Phase 2 (2007–2011), after they won two waste treatment facility projects, their success rate dramatically increased. During Phase 3 (2012–2016), they participated in 17 bids and won 10 projects (average success rate: 59%). They mainly participated in waste management projects and DBO-type[17] projects, where investment was made by the government and private companies and financing was not necessary.

After 2017, when Phase 4 began, their success rate increased further. Between 2017 and early 2021, they won 14 out of 17 bids (success rate: 82%), slightly widened the scope of their project business scheme, collaborated with a larger number of companies (see Section 4.2 for details) and became the representative company for all projects.

The strengthening of the tendering capability for PPP/PFI procurement positively impacted Hitachizosen's overall performance. Around 70% of the waste-to-energy plants they built in the last 10 years were procured as PPP/PFI projects, and PPP/PFI sales had a significant impact on their total sales, which, after the late stages of Phase 4, significantly increased: from 303 billion yen in 2011 to 409 billion yen in 2020.

4.2.5 Collaboration with Other Companies within a Project

In order to participate in the tender and delivery of PPP/PFI projects, Hitachizosen has collaborated with other companies and created a consortium. These other companies include construction and civil engineering companies, plant engineering companies, operation and maintenance (O&M) companies and waste management companies. Hitachizosen normally selects partner companies project-by-project, based on the tendering requirement from government[18].

An original PPP/PFI project database was built based on the data collected by PFI information[19] provided by PFI net. Table 4.4 shows the conditions for extracting PPP/PFI project data for analysis.

[17] DBO: Design-Build-Operate. A private company designs, builds and operates and the public sector pays for the initial design and construction costs, as in conventional projects.
[18] Based on an interview with plant engineering company A.
[19] PFI information: http://www.pfinet.jp/

Table 4.4: Conditions for extracting PPP/PFI project data for analysis

-	PPP/PFI projects procured in Japan
-	PPP/PFI projects Hitachizosen participated in
-	PPP/PFI projects contracted between 1 January 2002 and 20 July 2021

Especially after 2012, the number of member companies in a consortium tended to increase each year, with Hitachizosen often collaborating with more than 10 companies on single project (Figure 4.5). The average number of member companies throughout the whole period in a consortium of Hitachizosen. There are four types of companies Hitachizosen collaborated with: construction and civil engineering companies, waste management companies, operation and maintenance companies and plant engineering companies (Table 4.5).

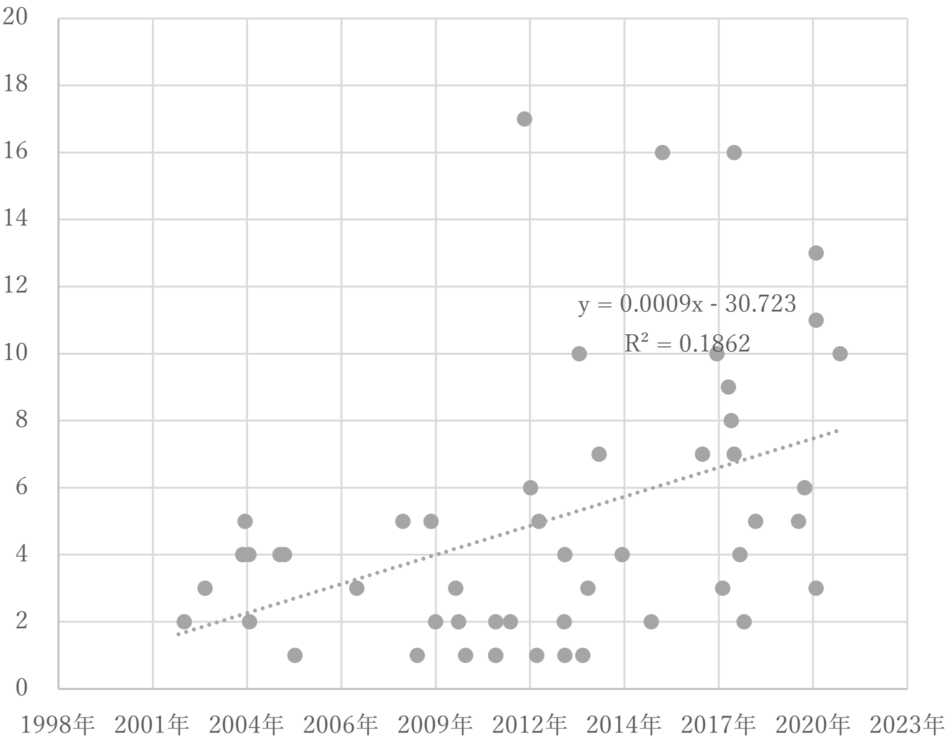

Figure 4.5: Number of member firms in a consortium (Hitachizosen)

Source: Own elaboration based on original PPP/PFI project database

First, because civil works require local networks to acquire human resources and materials on site[20], Hitachizosen collaborated with several local construction and civil engineering companies. Over the 20 years, the relationships between Hitachizosen and its partner companies were mostly one-off, implying that the field of civil works is highly standardised, that it is relatively easy to build collaborative relationships and that there is an abundance of companies to choose from.

Second, in recent years, mainly due to the public sector demand to widen the scope of PPP/PFI projects, Hitachizosen often collaborated with waste management companies that own facilities for waste treatment. Municipalities require the addition of ash treatment to the scope of PPP/PFI projects since their landfill sites lack capacity – this is a recent trend in Japanese waste management PPP/PFI projects, and Hitachizosen participated in more than 10 projects that included ash treatment: on average, Hitachizosen collaborated with 2–3 ash treatment companies and 2–3 waste transport companies per project for ash treatment. This is one of the main reasons for the increase in the number of consortium member companies. The project risk for ash treatment is normally separated from the main waste-to-energy incineration PPP/PFI projects, and co-working between the operation of the incineration plant and ash treatment is limited.

Third, Hitachizosen's collaborative relationship with O&M companies over the entire period was robust. Hitz Environment Services, a subsidiary of Hitachizosen, participated in more than half of Hitachizosen's PPP/PFI projects as an O&M company. Initially, Hitz Environment Services was divided into two companies by geographical area, but in 2015, the companies were merged into one to enhance operation management technology and service[21].

Fourth, Hitachizosen collaborated with plant engineering companies (such as Kyokuto Kaihatsu and Shin Meiwa), which could potentially be competitors.

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[20] Based on an interview with plant engineering company A

[21] Source: News release on Hitachizosen's website

As shown in Table 4.6, Hitachizosen collaborated with Kyokuto Kaihatsu on six projects and Shinmeiwa on one. Both Kyokuto Kaihatsu and Shin Meiwa dealt with the design, construction and operation of recycling facilities that use relatively simple technologies and systems. Kyokuto Kaihatsu also invested in Special Purpose Vehicles (SPVs) and managed recycling facilities throughout the project life cycle. Although Kyokuto Kaihatsu sometimes competed in the bidding for the recycling facilities of PPP/PFI projects, they collaborated on waste-to-energy incineration PPP/PFI projects.

Table 4.6: Hitachizosen's project collaboration with plant engineering companies

Company	Success/ Lost	Project	Contract year/month	Partner company	Role
Hitachizosen	Success	Mito city	2016/ Jan	Kyokuto	Stakeholder
Hitachizosen	Success	Otsu city	2017/ April	Kyokuto	Stakeholder
Hitachizosen	Success	Kasumidai area	2017/ Sep	Kyokuto	Stakeholder
Hitachizosen	Success	Usa/Takada/kunisak i area	2017/ Dec	Kyokuto	Stakeholder
Hitachizosen	Lost	Hamamatsu city	2018/ March	Kyokuto	Stakeholder
Hitachizosen	Lost	Kurashiki city south	2020/ July	Shinmeiwa	Stakeholder
Hitachizosen	Success	Nansatsu area	2021/ March	Kyokuto	Stakeholder

Finally, there were no joint applications for patents with partner companies in PPP/PFI projects except for with Hitachizosen's own subsidiaries, which clearly shows that collaboration in projects does not directly influence firms' R&D activities and technological capability.

4.2.6 Shift of the Role of Each Member Company

Hitachizosen's method of collaboration with other companies also shifted during the period under analysis. Table 4.7 shows the shift in the role of each member company. As they gained PPP/PFI project experience, Hitachizosen changed their role in the consortiums for these projects.

First, once they learned and managed these services, Hitachizosen collaborated with other companies. They gradually started concentrating on the role of project management and construction of the incinerator plant, which are the core services of waste management PPP/PFI projects[22] (i.e., operation and maintenance of incinerator, recycling facilities and buildings).

Second, collaborative capability also seems to be related to the accumulation of capability in the business ecosystem. The O&M company (Hitz Environment) and plant engineering company (Kyokuto and Shinmeiwa) were originally subcontractors, their roles limited under the control of Hitachizosen in the beginning of the PPP/PFI project (Phase 1 and Phase 2). However, Hitz Environment, Kyokuto and Shinmeiwa's capabilities gradually improved through their collaboration with Hitachizosen and others, and Hitachizosen asked them to invest in the project and manage facilities with autonomy as business partners.

Third, Hitachizosen seemed to recognise the importance of further collaboration with companies outside of their conventional business ecosystem in entering emerging business fields, such as the concession business of water treatment. Hitachizosen was also aware of the need to collaborate with companies such as IT companies and asset management companies.

Table 4.7: Shift in the role of each member company (Hitachizosen)

<table>
<tr><th colspan="3" rowspan="2">Type of service</th><th>Phase 1</th><th>Phase 2</th><th>Phase 3</th><th>Phase 4</th></tr>
<tr><th>2002–2006</th><th>2007–2011</th><th>2012–2016</th><th>2017–2021</th></tr>
<tr><td colspan="3">Project management</td><td>Others/ Hitachi zosen</td><td>Hitachi zosen</td><td>Hitachi zosen</td><td>Hitachi zosen</td></tr>
<tr><td rowspan="3">Construction</td><td rowspan="2">Plant</td><td>Incinerator</td><td>Hitachi zosen</td><td>Hitachi zosen</td><td>Hitachi zosen</td><td>Hitachi zosen</td></tr>
<tr><td>Recycling facilities</td><td>Hitachi zosen</td><td>Hitachi zosen</td><td>Hitachi zosen/ Kyokuto</td><td>Kyokuto/ Shinmeiwa/ Hitz Environment Service</td></tr>
<tr><td colspan="2">Building</td><td>Others/ Hitachi zosen</td><td>Others</td><td>Others</td><td>Others</td></tr>
<tr><td rowspan="3">Operation/ Maintenance</td><td rowspan="2">Plant</td><td>Incinerator</td><td>Hitachi zosen</td><td>Hitz Environment Service</td><td>Hitz Environment Service</td><td>Hitz Environment Service</td></tr>
<tr><td>Recycling facilities</td><td>Hitachi zosen</td><td>Hitz Environment Service</td><td>Hitz Environment Service/ Kyokuto</td><td>Kyokuto/ Shinmeiwa/ Hitz Environment Service</td></tr>
<tr><td colspan="2">Building</td><td>Hitachi zosen</td><td>Hitz Environment Service</td><td>Hitz Environment Service</td><td>Hitz Environment Service</td></tr>
<tr><td rowspan="2">Ash recycling</td><td colspan="2">Transportation</td><td>-</td><td>Others</td><td>Others</td><td>Others</td></tr>
<tr><td colspan="2">Recycling</td><td>-</td><td>Others</td><td>Others</td><td>Others</td></tr>
</table>

Source: Own elaboration based on the original database

[22] In regard to ash recycling treatment, Hitachizosen did not manage by themselves before collaboration. However, the business scheme of ash recycling is separate from waste treatment incineration facilities.

4.3 Ebara

4.3.1 Case Description

For the last two decades, over 1,400 PPP/PFI projects have been procured in the various fields of public service in Japan (e.g. schools, sports facilities, hospitals, and waste management facilities). In the field of waste management, in particular, PPP/PFI procurement has been actively introduced, with 205 projects already delivered.

Ebara is one of the most experienced plant engineering and construction companies in the field of waste management PPP/PFI projects. Based on the tendering information, between 1 January 2002 and 20 July 2021, Ebara participated in 52 bids for PPP/PFI projects and succeeded in procuring 20 of them. Ebara's main business is wind and hydro power facilities, and their second large business segment is environment plant (mainly a waste-to-energy plant[23]), which accounts for 13% of their total sales[24]. In the last 10 years, their environmental plant segment sales increased 1.3 times, from 50 billion yen in 2011 to 68 billion yen in 2020.

Ebara is a company headquartered in Ota-ku, Tokyo. Founded in 1912 as "Kuchi-type Machinery Office" to manufacture products based on Dr. Iguchi's theory of centrifugal pumps. 1955 Started sales expansion by standardization and mass production of small pumps. In 1985, started a new business project for the semiconductor industry. Globally develops three main products since its establishment: Feng Shui mechanical products and systems such as pumps, environmental business dealing with industrial waste incinerator plants, and precision and electronic business.

Ebara's main products are dry vacuum pumps and CMP equipment. Ebara also handles plating equipment, bump plating equipment, bevel polishing equipment, electron beam defect inspection equipment, etc. for next-generation

[23] Waste-to-energy is a technology for solid waste treatment and power generation by incineration or fermentation of waste.

[24] Ebara's annual sales total JPY67,547 million, and the sales of its environment and plant total JPY 523,727 million (as of 2020).

nodes. Ebara is aggressive in expanding overseas, and the overseas sales ratio is about 50%.

Ebara's total sales was 523,727 million JPY and sales of SWM-related business segment was 67,547 million JPY. Only 7.2% of total sales are from SWM-related business segment.

Ebara has shared its open financial data concerning sales and profit by SWM-related business segment. Table 4.8 shows the segment information.

Table 4.8: Products of Ebara's SWM-related business segment

Name of business segment	Products
Environmental plant	Engineering and construction, operation and maintenance of municipal waste incinerator plants, industrial waste incinerator plants, water treatment plants

4.3.2 Sales and Profit by SWM-related Business Segment

Figure 4.6 shows Ebara's sales and profit results for the related business segment between 2002 and 2020. Over the last decade, after they started participating in PPP/PFI projects, Ebara's sales significantly decreased; between 2006 and 2020, the CAGR of segment sales was -5.7%. However, in this period, especially after 2008, the segment profit slightly increased.

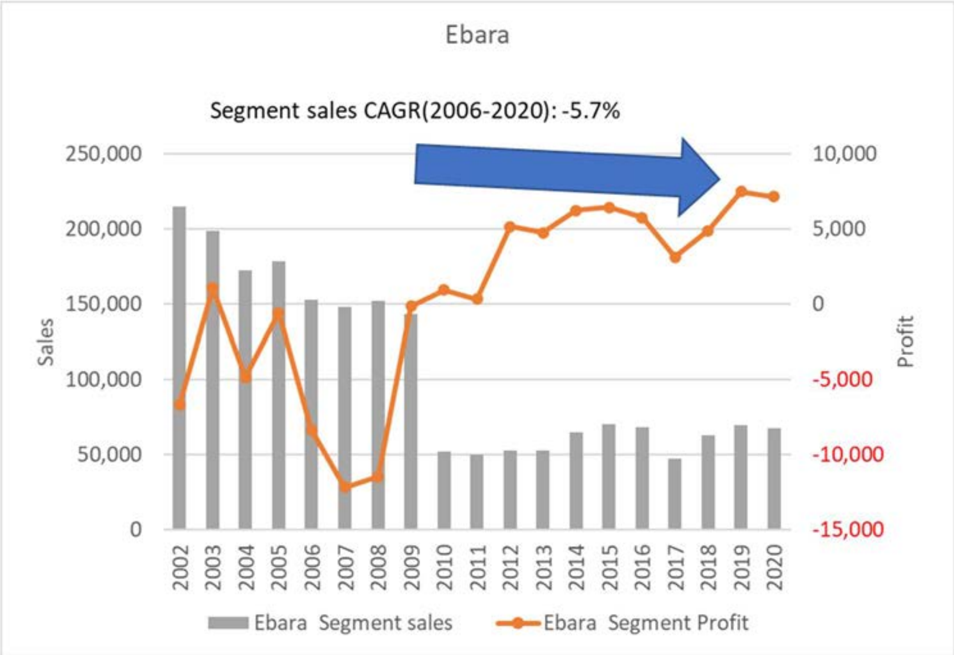

Figure 4.6: Sales and profit by SWM-related business segment

(SWM-related business segment: Environmental plant department)

4.3.3 Transition of Patent Registration and R&D Strategy

To understand the accumulation of technological capability, Ebara's patent data was analysed, and the results are shown in Figure 4.7. Table 4.9 shows the conditions for extracting patent data for analysis.

Table 4.9: Conditions for extracting patent data for analysis

-	Patent registered in Japan
-	Patent applied by Ebara
-	Patent applied between 1 January 1996 and 31 December 2020
-	Extract the following IPC code (FI code) patent information related to basic waste-to-energy technologies: B09B: waste treatment F23G: incinerator technology F23J: ash/residue treatment technology

Figure 4.7 shows the trend in the number of patents related to waste-to-energy technologies based on the four-digit IPC code (FI code). The analysis

revealed a shift in Ebara's patent concentration over the last 25 years. The cumulative total of number of patent registration during the last 25 years is 277.

Several related patents were applied before 2002, when Ebara started participating in PPP/PFI projects, similar to Hitachizosen. After 2002, the number of patents related to solid waste treatment technology then significantly decreased, implying that participation in and execution of PPP/PFI projects are not directly related to the number of registered patents.

Based on the annual reports as well as research papers Ebara published, the technological capability necessary for building and operating the waste treatment facilities was developed before Ebara started participating in PPP/PFI projects.

After participation, Ebara's interest in R&D activities shifted to O&M-related technology, as it started using information technologies such as remote monitoring systems and automated operating systems[25]. These technologies help save O&M costs, strengthen project capability for bidding and improve the level of O&M service.

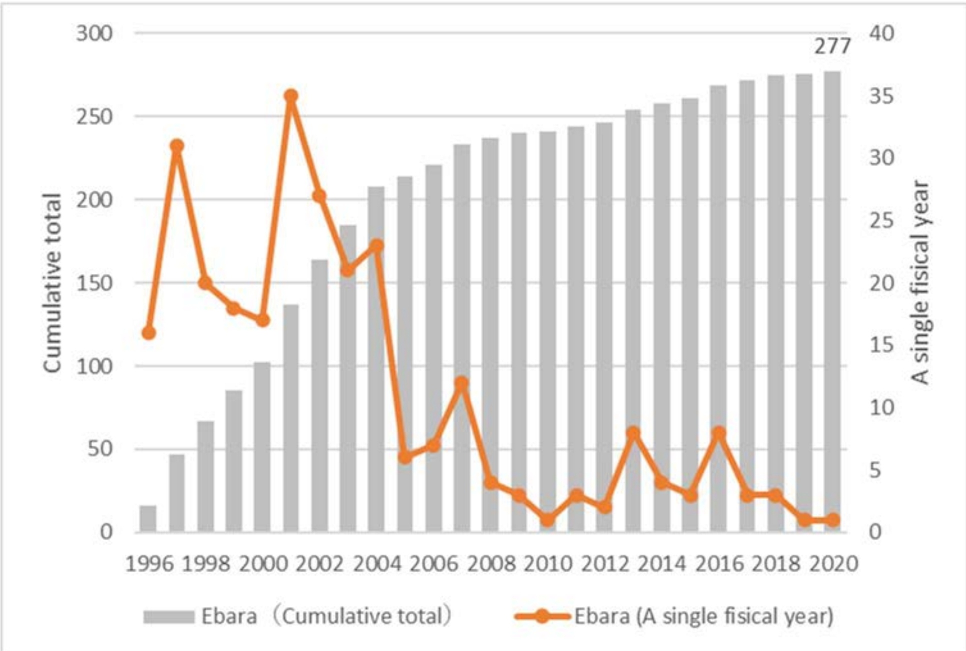

Figure 4.7: Number of patent registrations (Ebara)
(SWM-related technologies)

[25] Based on the annual reports of Ebara.

Figure 4.8 shows Ebara's research and development expenses for the SWM-related business segment between 2003 and 2020. Although it is difficult to compare Ebara's research and development expenses before and after they started participating in PPP/PFI projects in 2002 due to the data limitation, Figure 4.8 shows that Ebara spent their resources on R&D activities and accumulated technological capabilities to a certain extent even after participating in PPP/PFI projects. However, after 2009, their R&D expenses significantly reduced, which may be reflected in the drop in sales.

(Unit: Million Yen)

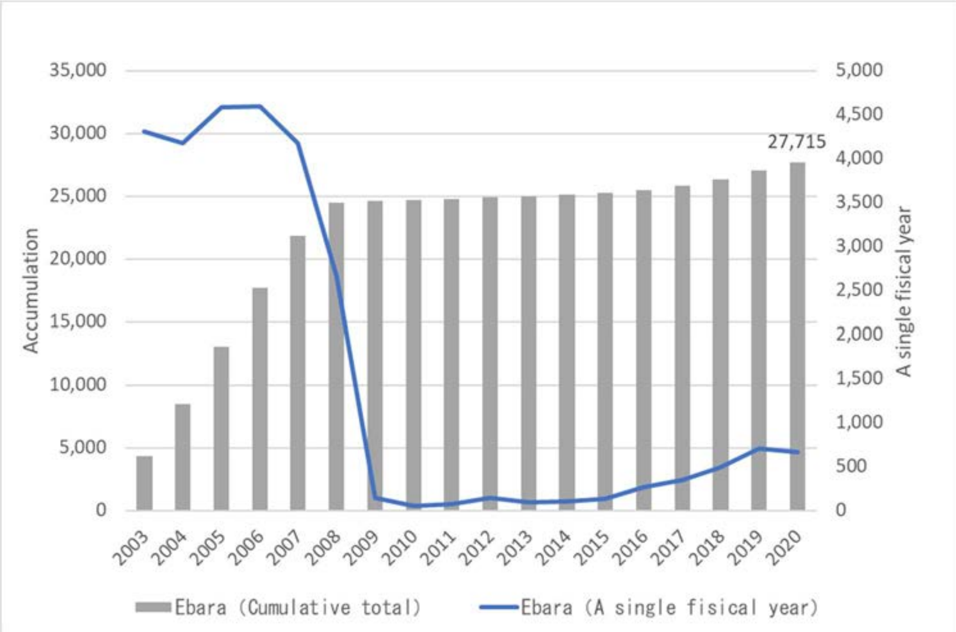

Figure 4.8: Research and development expenses by SWM-related business segment (Ebara)

(SWM-related business segment: Environmental plant department)

4.3.4 Shift in the Success Rate of PPP/PFI Project Bids

Ebara slightly accumulated project capability through their 20-year PPP/PFI project experience. To analyse the change in Ebara's success rate of PPP/PFI project bids, an original PPP/PFI project bidding information database was built based on the data collected by PFI information[26] provided by PFI net. Table 4.10 shows the conditions for extracting PPP/PFI project data for analysis.

Table 4.10: Conditions for extracting PPP/PFI project data for analysis

- PPP/PFI projects procured in Japan
- PPP/PFI projects Ebara participated in
- PPP/PFI projects contracted between 1 January 2002 and 20 July 2021

[26] PFI information: http://www.pfinet.jp/

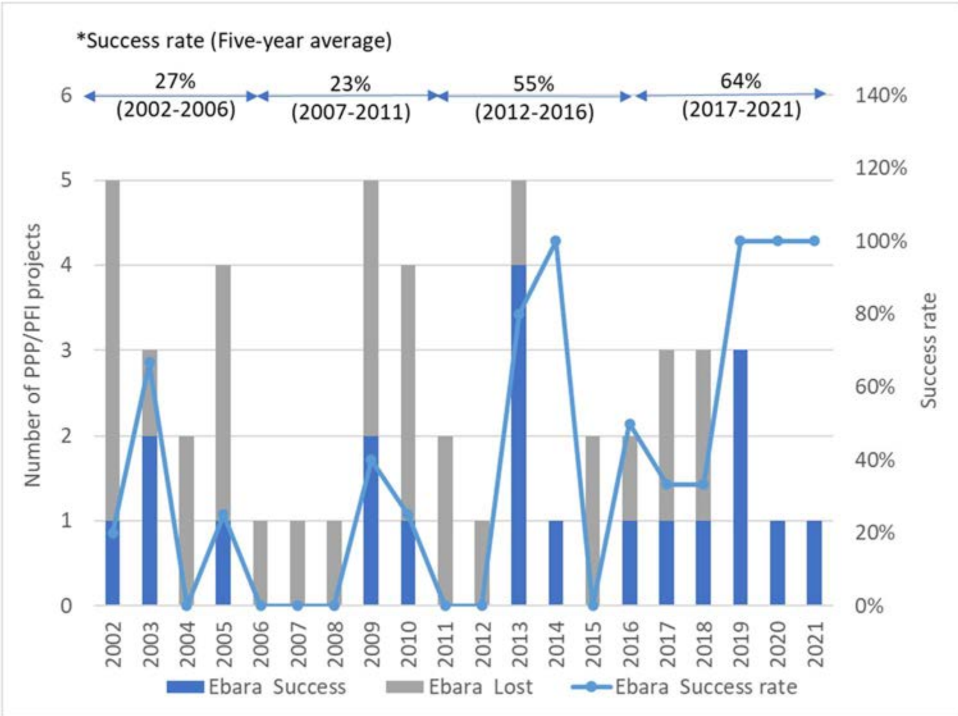

Figure 4.9: Shift in success rate of PPP/PFI projects based on the results of tendering (Ebara)

Source: Own elaboration based on original PPP/PFI project database

From 2002 until July 2021, Ebara participated in bids for 52 PPP/PFI projects, succeeding in procuring 20 of them (average success rate: 38%). The success rate, as shown in Figure 4.9, has grown ever since.

In the initial stage, Phase 1 (2002–2006), Ebara, like Hitachizosen, struggled to win bids for PPP/PFI projects, winning only five out of 15 bids in five years. They participated in bidding for waste management, energy management and water treatment projects.

During Phase 2 (2007–2011), their success rate slightly decreased to 23%, and during Phase 3 (2012–2016), they participated in 11 bids and won 6 projects (average success rate: 55%). They mainly participated in waste management projects and DBO-type[27] projects, where investment was made by the government and private companies and financing was not necessary.

[27] DBO: Design-Build-Operate. A private company designs, builds and operates, and the public sector, as in conventional projects, pays for the initial design and construction costs.

After 2017, when Phase 4 began, their success rate slightly increased. They won 7 projects out of 11 bids between 2017 and early 2021 (success rate: 64%).

The strengthening of the tendering capability for PPP/PFI procurement positively impacted Ebara's entire performance. After the late stages of Phase 4, their total sales significantly increased, growing from 412 billion yen in 2011 to 524 billion yen in 2020.

4.3.5 Collaboration with Other Companies within a Project

To participate in the tender and delivery of PPP/PFI projects, Ebara also collaborated with other companies and created a consortium. The other companies included construction and civil engineering companies, plant engineering companies, operation and maintenance (O&M) companies and waste management companies.

An original PPP/PFI project database was built based on the data collected by PFI information[28] provided by PFI net. Table 4.11 shows the conditions for extracting PPP/PFI project data for analysis.

Table 4.11: Conditions for extracting PPP/PFI project data for analysis

- PPP/PFI projects procured in Japan
- PPP/PFI projects Ebara participated in
- PPP/PFI projects contracted between 1 January 2002 and 20 July 2021

The number of member companies in Ebara's consortium decreased each year (Figure 4.10). Ebara rarely collaborated with more than 10 companies on single projects. The average number of member companies throughout the whole period in a consortium of Ebara is only 3.3.

[28] PFI information: http://www.pfinet.jp/

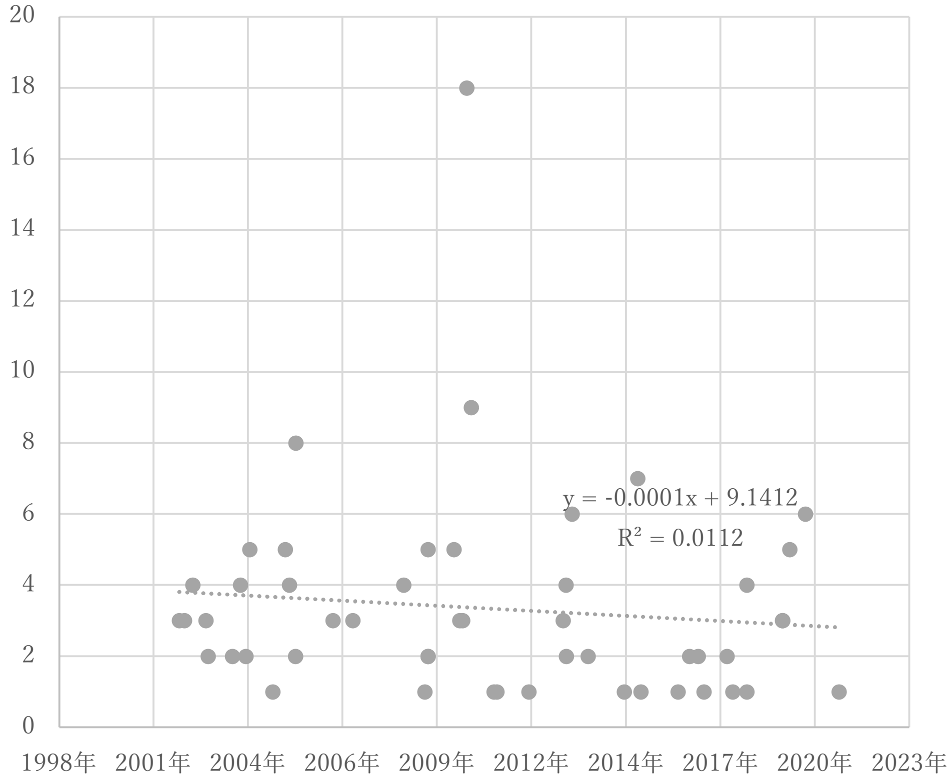

Figure 4.10: Number of member firms in a consortium (Ebara)

Source: Own elaboration based on original PPP/PFI project database

Ebara rarely collaborated with other plant engineering companies (such as Kyokuto Kaihatsu and Shinmeiwa), which could potentially be competitors. As shown in Table 4.12, Ebara collaborated with Shinmeiwa on only one project (Ebara lost the project). In the project, Shinmeiwa did not invest in SPVs and participated only as a sub-contractor. Shinmeiwa was responsible for the construction and operation of recycling facilities that use relatively simple technologies and systems. Moreover, Ebara did not participate in the bidding for the recycling facilities of PPP/PFI projects and thus did not compete with Shinmeiwa.

Table 4.12: Ebara's project collaboration with plant engineering companies

Company	Success/ Lost	Project	Contract year/month	Partner company	Role
Ebara	Lost	Saitama city	2010/July	Shinmeiwa	Subcontractor

4.3.6 Shift of the Role of Each Member Company

Ebara’s method of collaboration with other companies slightly changed during the period of analysis. As Table 4.13 shows, the change in Ebara’s role in consortiums for PPP/PFI projects was limited.

First, Ebara expanded their role in PPP/PFI projects as they gained experience. In contrast to Hitachizosen, Ebara gradually expanded its role to include project management, construction of recycling facilities, operation and maintenance of incinerator and recycling facilities and buildings. During Phase 3 and Phase 4, Ebara took on the main role in PPP/PFI projects.

Second, Ebara’s collaboration with other companies was limited throughout the analysis period. During Phase 1 and Phase 2, Ebara mainly collaborated with its group company, Ebara Engineering Service.

Table 4.13: Shift in the role of each member company (Ebara)

Type of service			Phase 1	Phase 2	Phase 3	Phase 4
			2002–2006	2007–2011	2012–2016	2017–2021
Project management			Others/ Ebara	Ebara	Ebara	Ebara
Construction	Plant	Incinerator	Ebara	Ebara	Ebara	Ebara
		Recycling facilities	Ebara	Ebara/ Shinmeiwa	Ebara	Ebara
	Building		Others	Others	Others	Others
Operation/ Maintenance	Plant	Incinerator	Ebara/ Ebara Engineering Service	Ebara/ Ebara Engineering Service	Ebara	Ebara
		Recycling facilities	Ebara	Ebara/ Shinmeiwa	Ebara	Ebara
	Building		Ebara	Ebara/ Ebara Engineering Service	Ebara	Ebara
Ash recycling	Transportation		-	Others	Others	-
	Recycling		-	Others	Others	-

4.4 Takuma

4.4.1 Case Description

From among the construction companies experienced in PPP/PFI projects, we selected Hitachizosen, Ebara and Takuma as cases for this study.

For the last two decades, over 1,400 PPP/PFI projects have been procured in the various fields of public service in Japan (e.g. schools, sports facilities, hospitals, and waste management facilities). In the field of waste management, in particular, PPP/PFI procurement has been actively introduced, with 205 projects already delivered.

Takuma is one of the most experienced plant engineering and construction companies in the field of waste management PPP/PFI projects. Based on the tendering information, Takuma participated in 39 bids for PPP/PFI projects, succeeding in procuring 18 of them between 1 January 2002 and 20 July 2021. Their main business is environment and energy (mainly a waste-to-energy plant[29]), which accounts for 82% of their total sales[30]. In the last 10 years, their environment and energy business segment sales increased 1.6 times, from 75 billion yen in 2011 to 121 billion yen in 2020, resulting in the rapid growth in total sales, which, after 2011, significantly increased: from 101 billion yen in 2011 to 147 billion yen in 2020.

Takuma is a boiler manufacturer headquartered in Amagasaki City, Hyogo Prefecture. In 1912, the founder, Takuma Tsunekichi, announced the first "Takuma-style can". In 1930 he was commended as one of the Ten Great Inventors of the Meiji and Taisho eras. Established Takuma Kikan Manufacturing Co., Ltd. in 1938 for the purpose of manufacturing boilers. In 1949, the stock was listed on Osaka and Tokyo, and the industry's first "bagasse-fired boiler" was exported. 1958 Entered the environmental equipment department such as waste incinerator plant and water treatment plant.

[29] Waste-to-energy is a technology for solid waste treatment and power generation by incineration or fermentation of waste.

[30] Takuma's annual sales total JPY146,726 million, and the sales of its environment and plant total JPY 120,770 million (as of 2020).

Takuma's current major products include boilers, mechanical equipment, pollution control plants, environmental equipment plants, heating and cooling and water supply and drainage sanitary equipment design, construction and supervision, civil engineering and construction, and other construction design, construction and supervision.

Takuma's total sales was 146,726 million JPY and sales of SWM-related business segment was 120,770 million JPY. 82% of total sales are from SWM-related business segment.

Takuma has shared their open financial data concerning sales and profit by SWM-related business segment. Table 4.14 shows the segment information.

Table 4.14: Products of Takuma's SWM-related business segment

Name of business segment	Products
Environment and energy	General waste treatment plant, industrial waste treatment plant, resource recovery plant, sewage treatment plant, sludge incineration plant, biomass power generation plant, gas turbine cogeneration system

4.4.2 Sales and Profit by SWM-related Business Segment

Figure 4.11 shows Takuma's sales and profit results for the related business segment between 2002 and 2020. Over the last decade, after they started participating in PPP/PFI projects, their segment sales and profit significantly increased; the CAGR of segment sales between 2006 and 2020 was 6.2%. (Takuma's financial data by segment between 2002 and 2005 was unavailable).

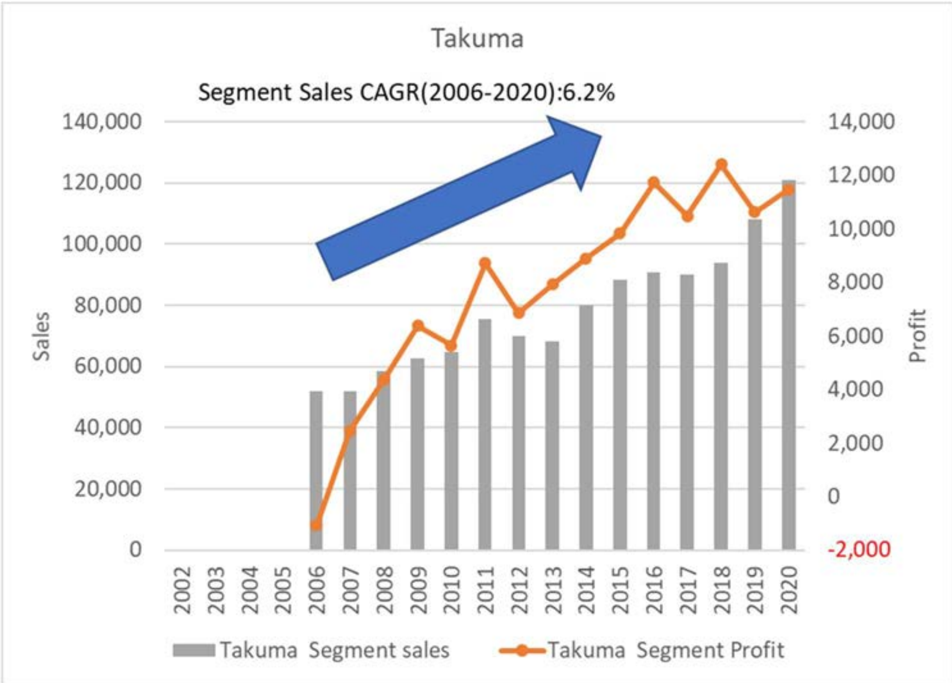

Figure 4.11: Sales and profit by SWM-related business segment

(SWM-related business segment: Environment and energy department)

4.4.3 Transition of Patent Registration and R&D Strategy

To understand the accumulation of technological capability, Takuma's patent data was analysed, and the results are shown in Figure 4.12. Table 4.15 shows the conditions for extracting patent data for analysis.

Table 4.15: Conditions for extracting patent data for analysis

- Patent registered in Japan
- Patent applied by Takuma
- Patent applied between 1 January 1996 and 31 December 2020
- Extract the following IPC code (FI code) patent information related to basic waste-to-energy technologies

  B09B: waste treatment

  F23G: incinerator technology

  F23J: ash/residue treatment technology

Figure 4.12 shows the trend in the number of patents related to waste-to-energy technologies based on the four-digit IPC code (FI code). The analysis revealed a shift in Takuma's patent concentration over the last 25 years. The cumulative total of number of patent registration during last 25 years is 395.

Several patents related to waste-to-energy technologies were applied before 2002, when Takuma started participating in PPP/PFI projects, similar to Hitachizosen and Ebara. The number of patents related to solid waste treatment technology slightly decreased after 2002, implying that the participation in and execution of PPP/PFI projects is not directly related to the number of registered patents.

Based on the annual reports as well as research papers Takuma published, the technological capability necessary for building and operating the waste treatment facilities was developed before Takuma participated in the PPP/PFI projects.

After participation, Takuma's interest in R&D activities moved to O&M-related technology, as it started using information technologies such as remote monitoring systems and automated operating systems[31]. These technologies help save O&M costs, strengthen project capability for bidding and improve the level of O&M service.

[31] Based on the annual reports of Ebara.

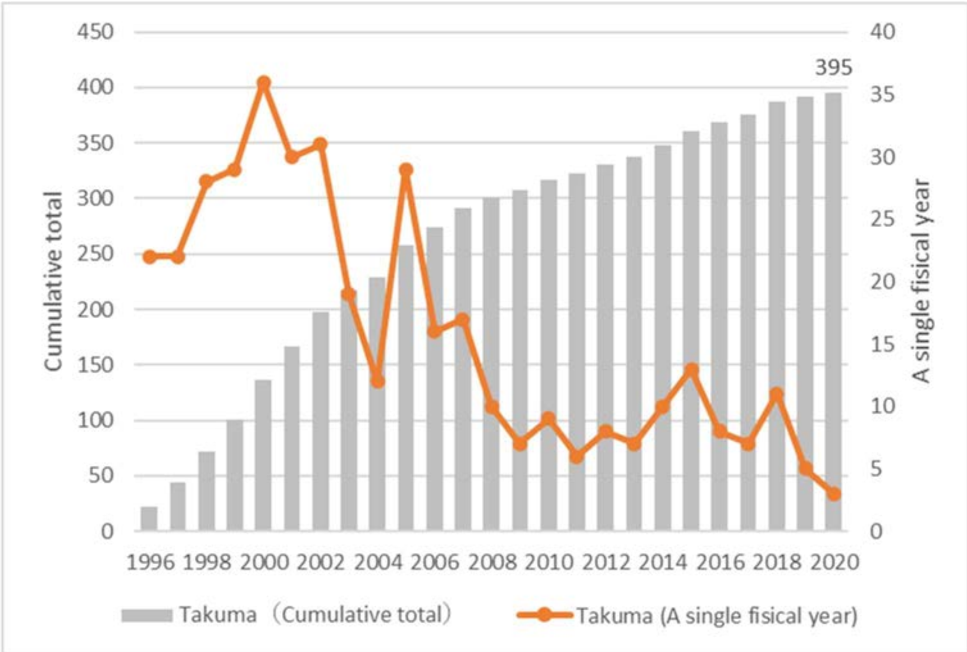

Figure 4.12: Number of patent registrations (Takuma)
(Solid waste treatment-related technologies)

Figure 4.13 shows Takuma's research and development expenses by SWM-related business segment between 2003 and 2020. Although it is difficult to compare research and development expenses before and after they started participating in PPP/PFI on 2002 due to the data limitation, Figure 4.13 shows that Takuma spent their resources on R&D activities and accumulated technological capabilities to a certain extent even after they started participating in PPP/PFI projects.

(Unit: Million Yen)

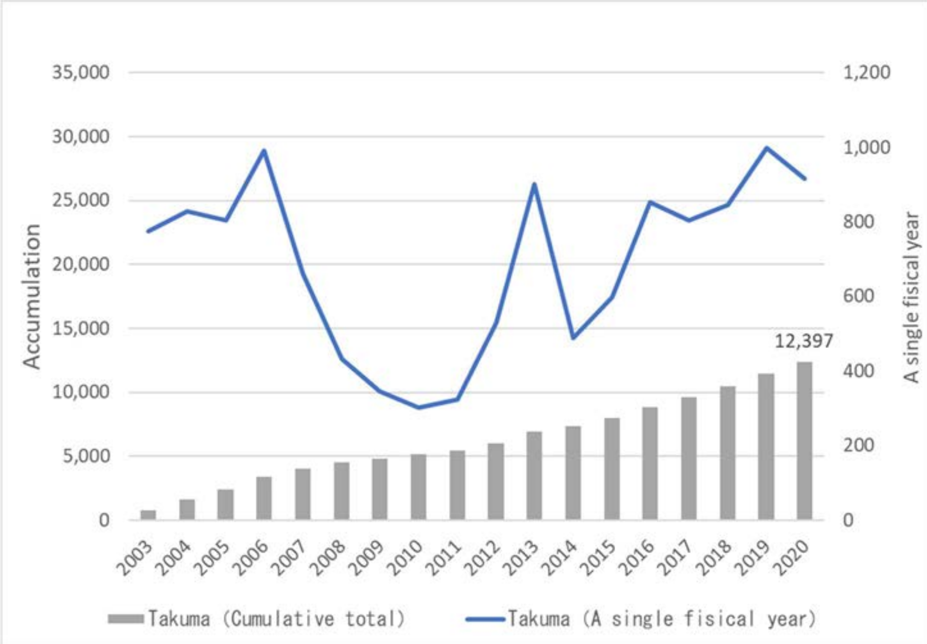

Figure 4.13: Research and development expenses by SWM-related business segment (Takuma)

(SWM-related business segment: Environment and energy department)

4.4.4 Shift in Success Rate of PPP/PFI Project Bids

Takuma, through their 20-year PPP/PFI project experience, slightly accumulated their project capability. To analyse the change in Ebara's success rate of PPP/PFI project bids, an original PPP/PFI project bidding information database was built based on the data collected by PFI information[32] provided by PFI net. Table 4.16 shows the conditions for extracting PPP/PFI project data for analysis.

Table 4.16: Conditions for extracting PPP/PFI project data for analysis

- PPP/PFI projects procured in Japan
- PPP/PFI projects Takuma participated in
- PPP/PFI projects contracted between 1 January 2002 and 20 July 2021

[32] PFI information: http://www.pfinet.jp/

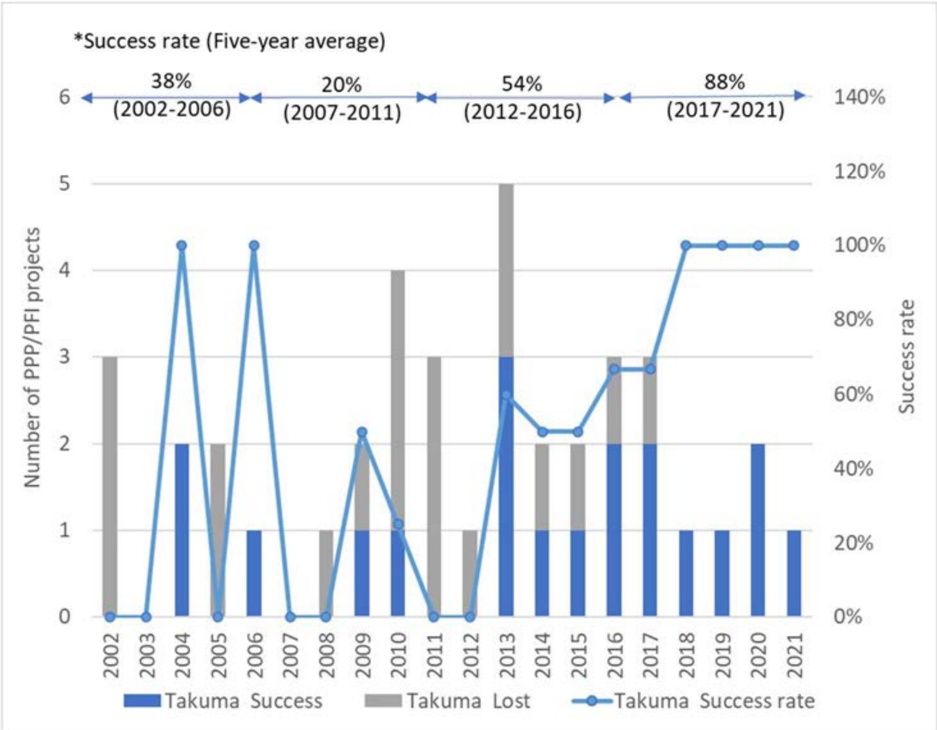

Figure 4.14: Shift in the success rate of PPP/PFI projects based on the results of tendering (Takuma)

Source: Own elaboration based on original PPP/PFI project database

From 2002 until July 2021, Takuma participated in bids for 36 PPP/PFI projects and succeeded in procuring 19 of them (average success rate: 49%). The success rate, as shown in Figure 4.14, has started growing ever since. In the initial stage, Phase 1 (2002–2006), Takuma had relative success in winning bids for PPP/PFI projects, winning three out of eight bids in five years. Most of their PPP participation projects were of the PFI, which required business investment, and they had to compete with not only engineering companies but also various investor-led consortiums.

However, during Phase 2 (2007–2011), their success rate reduced in half; they only won two out of 10 bids in five years. During Phase 3 (2012–2016), their success rate dramatically increased, and they participated in 13 bids and won seven projects (average success rate: 54%). They mainly participated in waste management projects and DBO-type[33] projects, where investment was

[33] DBO: Design-Build-Operate. A private company designs, builds and operates and the public sector pays for the initial design and construction costs, as in conventional projects.

made by the government and private companies and financing was not necessary.

After 2017, when Phase 4 began, their success rate increased further. Takuma won seven out of eight bids between 2017 and early 2021 (success rate: 88%).

Overall, during the 20 years of analysis period, Takuma bid only for waste management projects, and for most projects, they played the role of the representative company.

The strengthening of project capability for PPP/PFI procurement positively impacted Takuma's entire performance. PPP/PFI sales had a significant impact on their total sales, which, after the late stages of Phase 4, significantly increased, growing from 101 billion yen in 2011 to 147 billion yen in 2020.

4.4.5 Collaboration with Other Companies within a Project

To participate in the tender and delivery of PPP/PFI projects, Takuma also collaborated with other companies and created a consortium. These companies included construction and civil engineering companies, plant engineering companies, operation and maintenance (O&M) companies and waste management companies.

An original PPP/PFI project database was built based on the data collected by PFI information[34] provided by PFI net. Table 4.17 shows the conditions for extracting PPP/PFI project data for analysis.

Table 4.17: Conditions for extracting PPP/PFI project data for analysis

- PPP/PFI projects procured in Japan
- PPP/PFI projects Takuma participated in
- PPP/PFI projects contracted between 1 January 2002 and 20 July 2021

[34] PFI information: http://www.pfinet.jp/

The number of member companies in Takuma's consortium increased each year (Figure 4.15). Takuma rarely collaborated with more than 10 companies on single project – only three in the whole period. The average of the number of member companies in a consortium of Takuma is 3.8.

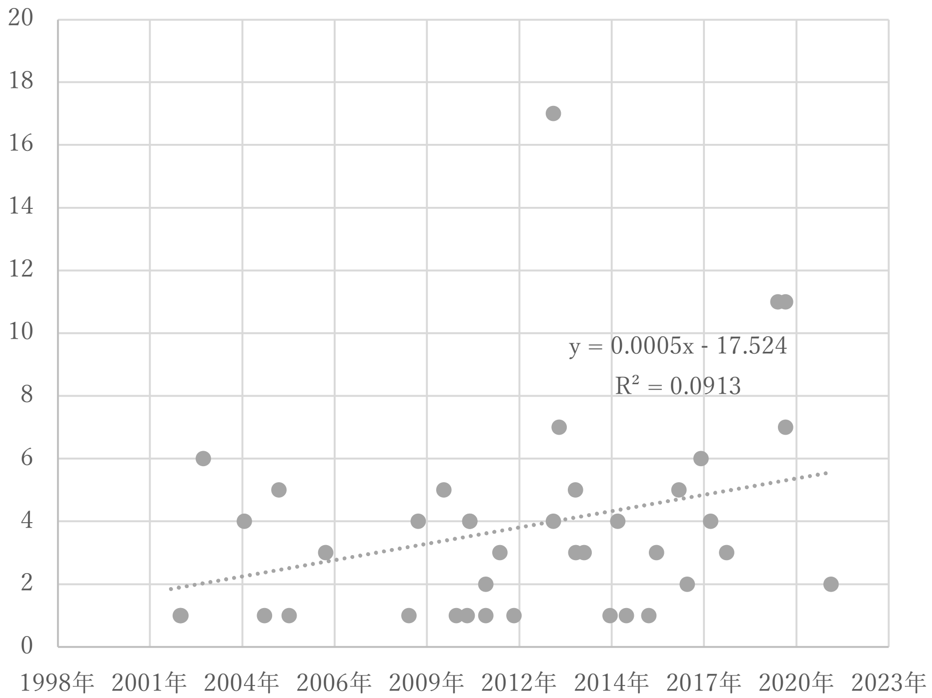

Figure 4.15: Number of member firms in a consortium (Takuma)
Source: Own elaboration based on original PPP/PFI project database

The partner companies of Takuma were mainly of four types: construction and civil engineering companies, waste management companies, operation and maintenance companies, and plant engineering companies.

First, as with Hitachizosen, Takuma always collaborated with several local construction and civil engineering companies. These relationships between Takuma and its partner companies were mostly one-off over the 20 years.

Second, Takuma had a robust collaborative relationship with O&M companies over the entire period. Takuma Technos, a subsidiary of Takuma, participated in more than half of Takuma's PPP/PFI projects as an O&M company.

Third, Takuma collaborated with plant engineering companies (such as Kyokuto Kaihatsu and Shinmeiwa), which could potentially be competitors. As shown in Table 4.18, Takuma collaborated with Kyokuto Kaihatsu on two projects and Shinmeiwa on one. Both Kyokuto Kaihatsu and Shin Meiwa dealt with the design, construction and operation of recycling facilities that use relatively simple technologies and systems. Kyokuto Kaihatsu and Shinmeiwa also invested in SPVs and managed recycling facilities throughout the project life cycle. Although Kyokuto Kaihatsu and Shinmeiwa sometimes competed in bidding for the recycling facilities of PPP/PFI projects, they also collaborated on waste-to-energy incineration PPP/PFI projects.

Table 4.18: Takuma's project collaborations with plant engineering companies

Company	Success/ Lost	Project	Contract year/ month	Partner company	Role
Takuma	Success	Kurume city	2013/ March	Shinmeiwa	Stakeholder
Takuma	Success	Funabashi city (North)	2013/ June	Kyokuto	Stakeholder
Takuma	Success	Komaoka (Yokohama city)	2020/ Feb	Kyokuto	Stakeholder

4.4.6 Shift of the Role of Each Member Company

Takuma's way of collaborating with other companies also shifted during the analysis period. As shown in Table 4.19, as they gained PPP/PFI project experience, Takuma changed their role in consortiums for PPP/PFI project.

First, Takuma collaborated with Takuma Technos from the beginning (Phase 1). Since Takuma Technos is an O&M company, it took the role of operating and maintaining the incinerator and recycling facilities and buildings.

Second, Takuma gradually concentrated on the role of project management and construction of the incinerator plant, the core services of waste management PPP/PFI projects[35]. Other works, such as construction of recycling facilities, operation and maintenance of incinerators, recycling facilities and buildings were conducted by the O&M company (Takuma) and plant engineering companies (Kyokuto and Shinmeiwa).

Table 4.19: Shift in the role of each member company (Takuma)

Type of service			Phase1	Phase2	Phase3	Phase4
			2002-2006	2007-2011	2012-2016	2017-2021
Project management			Others/ Takuma	Takuma	Takuma	Takuma
Construction	Plant	Incinerator	Takuma	Takuma	Takuma	Takuma
		Recycling facilities	Takuma	Takuma	Takuma/ Shinmeiwa/ Kyokuto	Takuma/ Kyokuto
	Building		Others	Others	Others	Others
Operation/ Maintenance	Plant	Incinerator	Takuma/ Takuma Technos	Takuma/ Takuma Technos	Takuma/ Takuma Technos	Takuma Technos
		Recycling facilities	Takuma/ Takuma Technos	Takuma/ Takuma Technos	Takuma/ Takuma Technos/ Shinmeiwa/ Kyokuto	Takuma Technos/ Kyokuto
	Building		Takuma/ Takuma Technos	Takuma/ Takuma Technos	Takuma/ Takuma Technos	Takuma Technos
Ashi recycling	Transportation		-	-	Others	Others
	Recycling		-	-	Others	Others

[35] In regard to ash recycling treatment, Hitachizosen did not manage by themselves before collaboration. However, the business scheme of ash recycling is separate from waste treatment incineration facilities.

4.5 Discussion

Table 4.20 shows the comparison of SWM-related business segments. Of note is the difference in sales CAGR of the three companies. Since 2002, after they started participating in PPP/PFI projects, the sales of the SWM-related business segment of Hitachizosen and Takuma increased, with CAGRs of 5.5% and 6.2%, respectively. On the other hand, the sales of the SWM-related business segments of Ebara decreased significantly, with its CAGR being -5.7%. Of course, although the impact of mergers and acquisitions (M&A) and organisational restructuring is expected, Hitachizosen and Takuma's performance in the waste-to-energy business-related departments increased after participating in PPP/PFI projects, while Ebara's deteriorated.

Table 4.20: Comparison of changes in sales

Firm	Sales[36] (Total) (Million Yen)	Sales[37] (SWM-related business segment) (Million Yen)	CAGR of Sales[38] (SWM-related business segment) (2006–2020)
Hitachizosen	408,592	270,278	5.5%
Ebara	523,727	67,547	-5.7%
Takuma	146,726	120,770	6.2%

4.5.1 Evolution of Technological Capability

The companies largely developed technological capability related to waste treatment facilities before they entered the PPP/PFI market. A large number of related patents were applied before 2002, when the focal companies started participating in the PPP/PFI projects. After 2002, the number of patent registrations related to solid waste treatment technology significantly decreased. Moreover, as Table 4.21 shows, the cumulative number of patent registrations (1996–2020) is not much different between the three companies.

Table 4.21: Patent registrations

[36] Based on the securities report of 2020
[37] Based on the securities report of 2020
[38] Based on the securities report between 2006 and 2020

Firm	Total of number of patent registrations (1996-2020)	R&D expenses by SWM-related business segment (2003-2020)
Hitachizosen	309	32,612
Ebara	277	27,715
Takuma	395	12,397

This data implies that participation in and execution of PPP/PFI projects is not highly related to the number of patents registered. A plant engineering company mentioned that they tend to use robust technology for PPP/PFI projects to lessen operational and maintenance risks. For the projects, as per the long-term PPP/PFI contract, the plant engineering company had to take on the risk of operating and maintaining the waste-to-energy facilities for 15–20 years. They thus were not strongly motivated to introduce cutting-edge technology, which may have led to the reduction in their number of patent registrations, especially those related to waste management technology (especially equipment-related technologies). These R&D trends based on the interview results also align with the R&D strategy stated in the plant engineering company's securities reports.

Some PPP/PFI studies (the Treasury Committee, 2011; Boardman et al., 2005) have highlighted the difficulty in fostering technological innovation. A possible reason for this is that the public sector tends to prefer robust and stable technologies that have been introduced in many other facilities[39]. In addition, since waste treatment facilities are large and complicated product systems, companies do not want to introduce drastically new technologies since doing so is risky. Our interviewees also mentioned similar issues:

Technologies in the field of waste management are already mature, and most municipalities prefer 'normal' technologies with 'low cost'. (Waste management association)

Although we make various proposals about technological innovation, we have a tendency to avoid risks by introducing real leading-edge technologies. (Plant engineering company A)

[39] Based on the interview with a waste management association

However, it was found that, even after participating in PPP/PFI projects, Hitachizosen, Ebara and Takuma actively invested in O&M, as they used information technologies such as remote monitoring systems and automated operating systems[40].

For example, in 2011, when they started to deliver operational services for several waste-to-energy plants of PPP/PFI arrangement, Hitachizosen introduced a monitoring system. After this, they started winning several PPP/PFI projects. Therefore, although there are examples of PPP/PFI projects hindering innovation, PPP/PFI projects can indeed foster incremental innovation and facilitate technological capability related to O&M services in construction firms, as in the case of the Japanese waste-to-energy PPP/PFI context, to a certain extent.

4.5.2 Evolution of Project Capability

Table 4.23 shows the comparison of the number of successes projects and the success rate of the PPP/PFI project bids of the focal companies. Project capability consist of two types of capability which the preparation of the bid and the execution of the project after winning the bids' project execution.

On the one hand, since entering the PPP/PFI business in 2002, Hitachizosen, Ebara, and Takuma, as they progressed through their phases, increased their bid rates. In particular, after 2017, when Phase 4 began, the success rate of Hitachizosen and Takuma significantly increased to 82% and 88%, respectively. Between 2017 and early 2021, Hitachizosen won 14 projects out of 17 bids. On the other hand, the success rate of Ebara did not increase much since 2017, only 64%, which is behind Hitachizosen and Takuma.

On the other hand, the number of successes projects indicates the project execution capability accumulated by project execution experiences. Hitachizosen has highly experienced based on 30 success projects, while Ebara and Takuma have only 20 and 17 success projects respectively.

[40] Based on the interview with and annual reports of Hitachizosen.

Table 4.22: Number of successes projects and success rate of PPP/PFI projects based on the results of tendering (2002–2021)

Firm	Number of Participations	Number of Successes	Success Rate
Hitachizosen	56	30	54%
Ebara	52	20	38%
Takuma	38	17	45%

Table 4.23: Comparison of success rate of PPP/PFI projects

Firm	Phase 1 2002–2006	Phase 2 2007–2011	Phase 3 2012–2016	Phase 4 2017–2021
Hitachizosen	20%	33%	59%	82%
Ebara	27%	23%	55%	64%
Takuma	38%	20%	54%	88%

The strengthening of the tendering capability for PPP/PFI procurement had a positive impact on firm performance. As noted from the interview with plant engineering company, around 70% of the waste-to-energy plants the plant engineering company built in the last 10 years were procured as PPP/PFI projects, and PPP/PFI sales had a significant impact on their total sales, which, after the late stages of Phase 4, significantly increased: from 303 billion yen in 2011 to 409 billion yen in 2020.

Project capability improved when Hitachizosen began to participate in bids for PPP/PFI projects and was accumulated, alongside organisational change, mainly in Phase 2. Although there are many types of project capabilities, as mentioned in previous research, we define capability of winning bids (proposal capability) and of delivering (project execution capability) PPP/PFI projects as project capability.

Based on the case study, we found that the transition of organisation structure for PPP/PFI project proposals positively impacted the accumulation of project capability by emphasising both external and internal learning effects.

In the early period, from Phase 1 to the middle of Phase 2, the sales and marketing PPP/PFI department –comprising people from backgrounds other than sales and marketing, such as engineering and commercial banking – managed the entire proposal process.

The PPP/PFI procurement process also needed to improve to improve the different capabilities, unlike bidding for conventional projects. Hitachizosen had to apply a comprehensive evaluation process, including technical proposals and business feasibility, and build long-term business projects by entering into contracts with consortium members and arranging financial investments.

In the early period, the PPP/PFI department accumulated proposal capability by learning from mainly external resources, using close relationships with other players in the business eco-system, such as clients (public sector), consultants and other construction companies. For example, the PPP/PFI association provided a simulative experience programme of feasibility study and bidding process of PPP/PFI projects for companies interested in the PPP/PFI business[41].

For creating proposals, a number of specialists on the proposal team of Hitachizosen, by collecting information and managing other departments, had a positive impact on the proposal process. For example, the sales and marketing specialists drove customer demand, the engineers communicated with the design and project management departments to write technical proposals and the finance department managed the project business plan with a financial consultant.

> *Because there are experienced engineers in the PPP/PFI department, proposal making could be managed in the sales and marketing department. The PPP/PFI project proposal-making process is highly complicated and requires a broad range of knowledge of both the business and technologies of waste-to-energy projects (Plant engineering company A).*

[41] Based on the interview with plant engineering company A.

In the later phase (mid-Phase 2 to Phase 3), Hitachizosen's organisation for proposal-making changed: the design department became the centre of the proposal team. Until then, the sales department had been actively implementing proposal management. After around 2013, a proposal room was created in the design department, and the proposals were mainly created there[42].

In this period, because both the construction firm side and the client side were experienced in PPP/PFI procurement, and because the business scheme of projects was routinised, the proposal needed to mention more detailed technological issues. Hitachizosen's design team has a close relationship with both construction and the operational team, meaning that they can easily get feedback from current PPP/PFI projects to improve the proposal and ensure a smooth transition to the project's execution phase[43].

In terms of project execution capability, Hitachizosen accumulated operational capability through its PPP/PFI projects. Although Hitachizosen operated waste-to-energy facilities for the public sector even before they participated in PPP/PFI projects, the contract was normally only a one-year contract, and Hitachizosen's autonomy was limited. Under the conventional project scheme, it was difficult to manage the recruitment and training of employees for operations from the long-term view. Maintenance and procurement information was collected and managed by the head office based on the remote monitoring system. It was under PPP/PFI that the comprehensive management of the entire life cycle of waste-to-energy plants became possible.

[42] Based on the interview with plant engineering company A.
[43] Based on the interview with plant engineering company A.

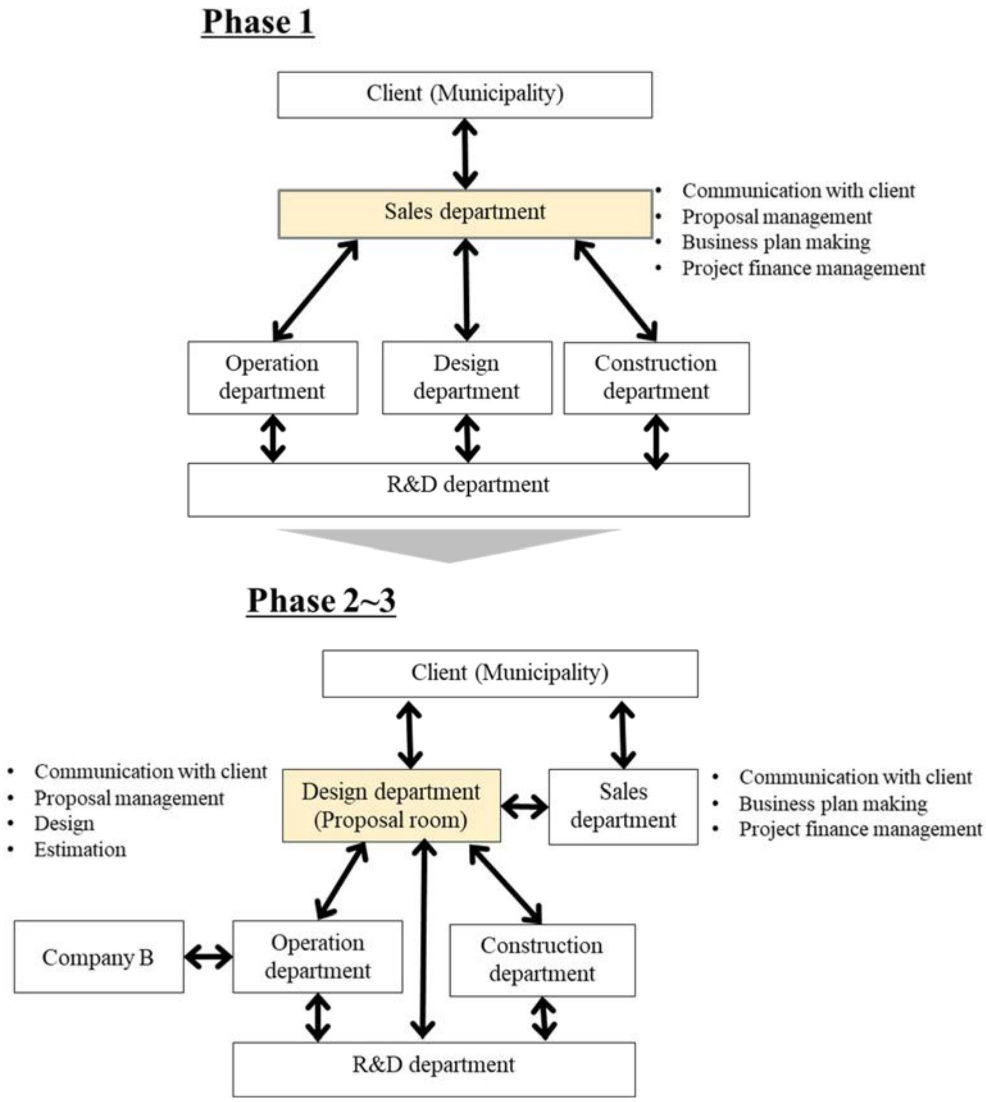

Figure 4.16: Shift of organisation for proposal making

4.5.3 Evolution of Collaborative Capability

Collaborative capability also facilitates the accumulation of further project capabilities. As mentioned above, PPP/PFI arrangements foster collaborations with local construction and civil engineering companies, and the field of civil works is highly standardised. It is relatively easy to build collaborative relationships, and there is an abundance of companies to choose from. However, the method and degree of collaboration with other companies differed among the three companies.

Table 4.24 shows the summary of the focal firms' collaboration in PPP/PFI projects. The number of companies within the Hitachizosen consortium increased rapidly as they started collaborating with many companies. Especially since 2012, Hitachizosen often collaborated with more than 10 companies (the average of the number of member companies is 5.0). Compared to Hitachizosen, Ebara and Takuma's collaboration with other companies was limited. Both Ebara and Takuma rarely collaborated with over 10 companies on one project (the average of the number of member companies was 3.3 and 3.8, respectively). In particular, the number of member companies in Ebara's consortium decreased with each year.

Table 4.24: Summary of collaboration in PPP/PFI projects

Firm	Number of member firms in a consortium	Average of the number of member firms
Hitachizosen	・The number of member companies in a consortium tended to increase each year, especially after 2012 ・Often collaborated with over 10 companies on one project	5.0
Ebara	・The number of member companies in Ebara's consortium decreased with each year ・Rarely collaborated with over 10 companies on one project	3.3
Takuma	・The number of member companies in Takuma's consortium increased each year ・Rarely collaborated with more than 10 companies on one project	3.8

Table 4.25 summarises the focal firms' collaboration with their competitors. As shown above, Hitachizosen and Takuma collaborated even with competitors, while Ebara wasn't largely active in collaborating.

For PPP/PFI arrangements, to offer a wide range of services, construction firms need to foster collaboration with various actors. Since the scope of PPP/PFI projects is much wider than that of conventional construction projects, the role of a construction firm as a leading company in a consortium has also become wider. To undertake these PPP/PFI projects and deliver a wide range of services through SPVs, construction firms must collaborate with other companies, such as design and maintenance firms.

Hitachizosen and Takuma collaborated even with competitors and not only design and maintenance firms. By working with competitors, they were able to improve not only their collaboration capabilities but also their project capabilities and performance. Hitachizosen/Takuma and Kyokuto/ ShinMaywa cooperated with and complemented each other by making the best use of their respective fields of expertise. This resulted in synergy.

Table 4.25: Summary of collaboration with competitors

Firm	Collaboration with competitors
Hitachizosen	・Collaborated with competitors (Kyokuto Kaihatsu and Shinmeiwa) for seven projects ・Kyokuto Kaihatsu also invested in SPVs and managed recycling facilities
Ebara	・Collaborated with Shinmeiwa on one project ・Ebara and Shinmeiwa did not compete in other projects ・Shinmeiwa did not invest in SPVs
Takuma	・Collaborated with competitors (Kyokuto Kaihatsu and Shinmeiwa) on three projects ・Kyokuto Kaihatsu and Shinmeiwa also invested in SPVs and managed recycling facilities

Moreover, collaborative capability seems to be also related to the accumulation of capability in the business ecosystem. According to the interview with plant engineering company A, their competitors (Kyokuto Kaihatsu and Shinmeiwa) were originally subcontractors, and their role was limited under the control of plant engineering company A at the beginning of the PPP/PFI project (in Phase 1 and Phase 2). However, the competitors' capabilities gradually improved through their collaboration with plant engineering company A and others, and plant engineering company A asked them to invest in the project and manage facilities with autonomy as business partners.

As shown in Table 4.26, the focal firms' role in consortiums for PPP/PFI projects changed, and the collaboration strategy of Hitachizosen and Takuma are different from that of Ebara. On the one hand, Hitachizosen and Takuma gradually concentrated on the role of project management and construction of the incinerator plant, which are the core services of waste management PPP/PFI projects [44]. Once they learned and managed these services, Hitachizosen collaborated with other companies on services except the core ones. From these facts, it is considered that Hitachizosen and Takuma took the strategy of 'concentration in core competence' that can be value-added when collaborating with other companies. In addition, by collaborating with business partners on a joint bid, it is thought that projects risks can be shared, and it also contributes to improve their performance.

On the other hand, Ebara expanded its role to include project management, construction of recycling facilities, operation and maintenance of incinerators, recycling facilities and buildings. During Phase 3 and Phase 4, Ebara took on the entire responsibility for PPP/PFI projects.

Table 4.26: Shift of the role of each member company

Firm	Role
Hitachizosen	・Hitachizosen gradually concentrated on the role of project management and construction of the incinerator plant, which are the core services of waste management PPP/PFI projects
Ebara	・Expanded its role to project management, construction of recycling facilities, operation and maintenance of incinerator, recycling facilities and buildings. ・In Phase 3 and Phase 4, Ebara took on the entire responsibility for PPP/PFI projects.
Takuma	・Takuma gradually concentrated on the role of project management and construction of the incinerator plant, which are the core services of waste management PPP/PFI projects. ・Other works such as construction of recycling facilities, operation and maintenance of incinerator and recycling facilities and buildings were conducted by an O&M company (Takuma) and plant engineering companies (Kyokuto and Shinmeiwa).

4.5.4 Dynamics of the Three Types of Organisational Capability through PPP/PFI arrangement

In this section, we summarise the evolution of construction firms' three capabilities: technological capability, project capability and collaborative capability under the firms' strategy by answering the R.Q.1. To measure them, we suggested several indicators (shown in Table 4.27).

R.Q.1: How have construction firms' organisational capability evolved to provide PPP/PFI services for the public sector?

Table 4.27: Indicators for measuring organisational capabilities

Categories	Indicators
Performance	- Sales - Profit
Technological capability	- Patent registration - R&D expenses - R&D strategy
Project capability	- Number of conducted PPP/PFI projects - Shift of success rate of PPP/PFI bids
Collaborative capability	- Number of member firms in a consortium - Collaboration with competitors - Shift of the role of each member company

Table 4.28 summarises the focal firms' evolution of organisational capability through PPP/PFI arrangement.

In terms of performance, Hitachizosen and Takuma witnessed a positive impact of participating in PPP/PFI projects unlike Ebara, which witnessed a dramatic decrease in their related sales. The result of performance would be related to the evolution of organisational capability through PPP/PFI arrangement.

As shown in Table 4.28, the number of patent registrations related to solid waste treatment technology significantly decreased after 2002. Moreover, as

Table 4.28 shows, the cumulative number of patent registrations (1996–2020) is not much different between the three target companies, implying that participation in and execution of PPP/PFI projects is not directly related to the number of registered patents.

Project capability, in contrast, shows a clear difference between the three companies, especially in Phase 4 (2017–2021). Hitachizosen and Takuma's success rates increased significantly over the period, reaching 82% and 84% in Phase 4, respectively, while Ebara's success rate was only 64%. It is thought that one of these major factors could account for the difference in collaborative capability with external actors.

Hitachizosen actively collaborated with many external actors and also with sometimes competing plant manufacturers, such as Kyokuto Kaihatsu and ShinMaywa. Although Takuma is collaborated limited number of external actors, it also collaborated with external actors and actively promoted collaboration with competitors and group companies. On the other hand, Ebara largely executed the project within the company; its cooperation with external actors decreased and with competitors was limited.

These differences in collaboration capabilities exerted a significant impact on the differences in performance between the three firms, and the interviews with plant engineering companies and a waste management association revealed the importance of collaborative capability.

Table 4.28: Evolution of organisational capability through PPP/PFI arrangement

Categories	Hitachizosen	Ebara	Takuma
Performance	Positive	Negative	Positive
Technological capability	Accumulated but the number of patent registrations decreased	Accumulated but the number of patent registrations decreased	Accumulated but the number of patent registrations decreased
Project capability	Success rate increased	Success rate dropped in Phase4 (2017–2021)	Success rate increased

Collaborative capability	Collaborated with many external actors (average 5.0 companies), even competitors	Collaborated with limited external actors (average 3.3 companies)	Collaborated with limited external actors (average 3.8 companies), even competitors

This study found that, to respond to the institutional shift towards PPP/PFI arrangements, Hitachizosen accumulated three types of organisational capabilities: technological capability, project capability and orchestration capability. These capability dynamics of construction firms changed over time through waste treatment PPP/PFI projects (Figure 4.17).

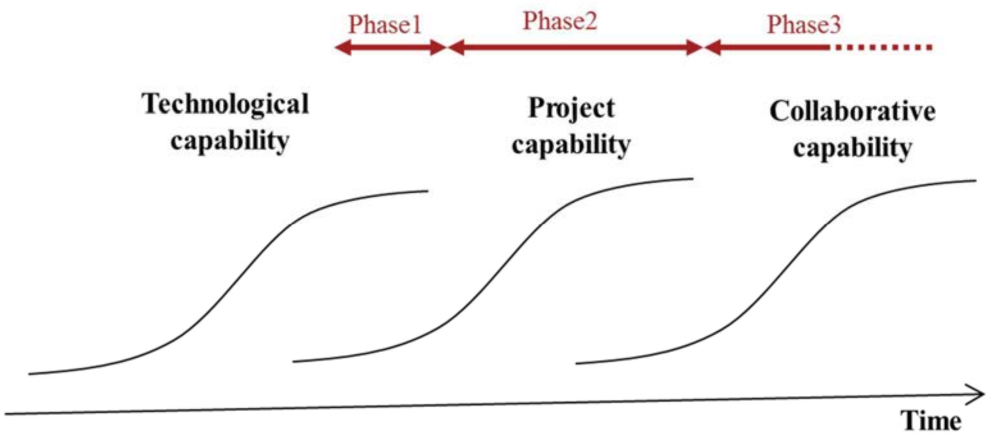

Figure 4.17: The capability development model of PPP/PFI arrangement

4.5.5 Mechanisms behind How Collaborative Capability Affects Construction Firms' Organisational Capabilities

In this section, we discuss the mechanisms behind how collaborative capability affects construction firms' organisational capabilities by answering the R.Q.2.

R.Q.2: Why do construction firms' organisational capabilities evolve through PPP/PFI arrangements under their strategy?

From the analysis of dynamics organisational capability, we found that the accumulation of collaborative capabilities would exert a significant impact on the differences in performance between Hitachizosen, Takuma, and Ebara. Here, we discuss the mechanisms behind how collaborative capability affects construction firms' organisational capabilities by answering the R.Q.2. 'Co-opetition' would be a key concept to explain the mechanisms

As we mentioned in the previous chapter, co-opetition would be considered difficult for many companies. The reason is that although co-opetition takes time and cost to make adjustments when collaborating, it does not much lead to improvement in performance, and it is difficult to obtain benefits for the company. In addition, for the project-based organisation such as the construction company, there is concern about leakage of know-how and weakening of the company's capabilities by collaborating in a long-term PPP/PFI project which is the construction company's main production base.

Despite of the increasing importance of concept of co-opetition (Gnyawali and Park, 2011; Walley 2007), it has not been adequately examined, especially in the field of project-based organisations such as construction firms. According to the analysis results of this study, Hitachi Zosen and Takuma, which accumulated capability to collaborate with competitors, showed higher performance than Ebara. Here, we discuss the mechanisms behind their co-opetition strategy.

4.5.5.1 Motivation of the construction companies for collaboration with competitors

First, construction companies originally had many subcontractors and they are specialised in project management. In general, it is common practice for construction companies to collaborate with other companies on a project-by-project basis (Gann and Salter, 2000). Although Hitachizosen/Takuma have some fields of competition with Kyokuto and ShinMaywa (e.g. design, construction, and operation of large-scale recycling facilities PPP/PFI project), their core business fields are different. On the one hand, Hitachizosen/Takuma's core business is the design, construction and operation of incinerators and boilers for waste-to-energy (incinerator). On the other hand, Kyokuto/ShinMaywa is good at designing and constructing recycling facilities (crushing/sorting facilities). Therefore, especially in the PPP/PFI business, in which a waste-to-energy facility with a recycling facility is packaged, Hitachizosen/Takuma and Kyokuto/ShinMaywa cooperated with each other and made the best use of their respective fields of expertise to complement each other. This resulted in synergy. Therefore, it is presumed that the motivation to collaborate with each other worked.

Second, in a PPP/PFI project, it is easy to clarify the division of duties for each facility (incinerator/recycling facility), and it takes less time and effort to coordinate when collaborating. In general, the specifications of PPP/PFI projects are described in detail when ordering projects from local governments, compared to conventional orders, and the business contents of each facility, such as incinerator facilities and recycling facilities, are clearly shown. Therefore, even when multiple companies collaborate in business execution, if they can clearly understand the division of duties from the bidding stage, there are relatively few problems during business execution. In addition, even when coordination is required between operations, it is possible to manage the project with the minimum necessary information sharing.

Third, the main factor that differentiates other companies from construction companies is the manufacturing know-how of manufacturing large equipment and the life cycle of facilities. Since it is difficult to imitate these abilities, it also poses a hurdle to cooperation and is considered to be a factor that lowers it. According to Gnyawali and Park (2011), one of the difficulties in collaborating with competitors is sharing knowledge between companies due to the confidentiality of information. However, as per the capabilities of construction companies desired for PPP/PFI projects, they should produce large-scale facilities at a reasonable cost, and they should operate long-term projects for about 20 years in a stable manner[45]. Therefore, in the PPP/PFI business market, a huge investment or a long period of time is required for a construction company to obtain a differentiating factor, such as efficient manufacturing of large equipment and operation know-how of the facility life cycle. Experience-based tacit knowledge may also be required. Therefore, even if some cooperation is conducted on a project basis and information is shared, there is little risk that the core know-how will be transferred (in other words, it will be stolen) immediately.

Why were three cases divided into companies that can take in competition (Hitachizosen and Takuma) and companies that cannot (Ebara)? First, Hitachizosen and Takuma are not as large as Ebara in terms of organisational size and number of personnel. Therefore, in the market situation where PPP/PFI projects are increasing rapidly, external support was needed, and it was necessary to focus more on one's own core business. On the other hand, Ebara has an abundant organisation size and number of personnel compared to Hitachizosen and Takuma. Therefore, it was possible for Ebara to respond to the fluctuations in the number of projects in the waste power generation PPP/PFI market with internal resources to some extent, and there was a tendency to conduct a wide range of operations in-house rather than placing an external order.

[45] According to the criteria for selecting operators for PPP / PFI projects, "stable operation" is cited as an evaluation criterion. At the time of bidding, the winning bidder is determined by a comprehensive evaluation of these qualitative aspects and business costs.

Second, construction companies such as Hitachizosen and Takuma have both equipment manufacturers and engineering functions. Therefore, even when designing and constructing a plant facility, such as a waste-to-energy facility, there is pressure to use the company's own equipment (i.e., crusher) as much as possible. Therefore, it may sometimes be necessary to select equipment whose performance and cost are not optimal. According to the interview with plant engineering company A, the company's crusher does not have a general-purpose machine and is made to order, so if it is a small scale, there will be a cost disadvantage, which makes it necessary to introduce equipment from other companies:

Although it is not uncommon to carry out engineering alone, businesses that can introduce their own products company-wide have a higher priority, and it is difficult for them to decide to devote their own personnel to engineering internally. And if you have done EPC for the recycling facility, I think that it is better to have you also invest in the operation and business, so the business that the design and construction company of the recycling facility operates and invests in It has been increasing recently.

Whether or not to invest depends on the ordering conditions, but if the business such as the recycling business is to be managed independently even partially, I think that it should be invested even if it is not the ordering conditions. (plant engineering company A)

On the other hand, there is a concern that external procurement will increase the margin and may have a disadvantage to the price. However, unlike ordinary construction, which involves an order/subcontractor, in the case of PPP/PFI projects, partner companies make proposals together from the bidding stage to determine prices to receive project orders from local governments. For this reason, both Hitachizosen/Takuma and Kyokuto/ShinMaywa were motivated to reduce prices. It is a bidding method that can prevent either one from adding an extra margin. In addition, both Hitachizosen and Takuma are familiar with the price structure, and it was easy to control the prices since they may carry out the roles played by Kyokuto and ShinMaywa in-house. This point also contributes to the reduction of margins through external procurement. In other words, for Ebara, the complementary effect of collaborating with other companies was difficult to understand due to its large organisation and abundant resources.

Third, in terms of sales, for Hitachizosen and Takuma, the orders received from the PPP/PFI business accounted for a large proportion of their company-wide sales. Therefore, it is considered that an organisational structure will be established for receiving orders in the PPP/PFI business, and the decisions will be made with an emphasis on receiving orders for PPP/PFI projects. Therefore, the voice of the department of the PPP/PFI business is greater than the voice of the department as an equipment manufacturer. On the other hand, Ebara had a lower ratio of orders received from the PPP/PFI business to company-wide sales than Hitachizosen/Takuma. Therefore, it may be difficult to make decisions that prioritise orders as an equipment manufacturer. Therefore, Ebara couldn't select the equipment with the best performance and price, and it is expected that orders in the PPP/PFI business will be missed.

4.5.5.2 Mechanisms behind how collaboration with competition improve the performance of construction companies

First, it is conceivable that Hitachizosen and Takuma were able to flexibly respond to the volatile market by cooperating with the competitors. In general, the number of orders placed in the PPP/PFI market fluctuates greatly from year to year, and construction companies need resource management in response to market changes. However, the human resources of each company are limited, and according to interviews with construction companies, whether to participate in the ordered business depends on whether their personnel can handle it. By collaborating with competitors, the number of bids that can be participated in will increase, the ability to propose technology will improve, the number of businesses that can be implemented will increase, and other capabilities, especially project capability, will be positively affected. Especially in areas such as construction companies, which have a long life cycle of design, manufacturing and operation, and where capability building takes time, the flexibility of human resources by collaborating with competitors will work effectively.

Second, with the participation of a recycling company called Kyokuto and Shinmeiwa, the knowledge based on abundant experience can be reflected in proposals at the time of bidding. It effectively works on orders for the PPP/PFI business, which is a bidding method that comprehensively evaluates not only prices but also technical proposals. It also effectively improves the efficient quality of PPP/PFI projects, including long-term operations. As shown in an interview with a representative of a waste management association, it could be a differentiating factor as the technical differences between the companies are becoming smaller.

We have reviewed many technical proposals for PPP/PFI projects, but all companies have a wealth of experience in making technical proposals when selecting a business operator for waste treatment projects. In that sense, waste treatment technology is already mature, and the technical difference is small for all construction companies. We recognize that there is almost no technical difference between the six major waste treatment companies, and I feel that creating added value through additional services is the key to selection. (Waste management association)

In particular, in the waste-to-energy PPP/PFI business, reduction of life cycle cost is an important factor. By procuring the plant of the recycling facility not from the inside but from the outside, including the competition, it can be procured at the market cost, and it is expected that the price competitiveness will increase. As mentioned above, there are many types of crushers in Kyokuto Kaihatsu and ShinMaywa, and project costs can be reduced. Therefore, it is probable that Hitachizosen and Takumam, by collaborating with them, were able to make proposals with increased price competitiveness.

Furthermore, needs of municipalities have changed to the ability to implement various peripheral projects such as energy utilization and disaster response by operating SWM facilities (see Figure 4.18). It leads construction company to collaborate with wider-range of companies. Also, it lessens motivation of the construction companies to accumulate core-SWM technologies).

Our interviewees also mentioned:

Technology of solid waste treatment is already mature and the technical differences between construction companies are limited. Therefore, it is recognised that there is almost no difference in the core incinerator technology of major construction companies. Rather, the differentiating factor is the capability to implement various peripheral projects such as energy utilization and disaster response. (Waste management association)

Collaborative capability would provide further project capabilities accumulation.

Figure:4.18 Change of award criteria of PPP/PFI projects

Award criteria	Score of Narumi	Score of Hamamatsu	Difference (% base)
Year of the bid	2004	2018	-
Non-price criteria	100 (100%)	150 (100%)	-
Project plan	8 (8%)	6 (4%)	▲4%
Facility layout	12 (12%)	30 (20%)	+8%
Stability of the waste processing technology	26 (26%)	16 (11%)	▲15%
Operation and maintenance plan	15 (15%)	22 (15%)	0%
Environmental sustainability (e.g. Reduction of final disposal/recycling of residues)	24 (24%)	32 (21%)	▲3%
Business plan	12 (12%)	16 (11%)	▲1%
Regional contribution	3 (3%)	14 (9%)	+6%
Disaster prevention	-	14 (9%)	+6%
Bidding price	100	50	-
Total	200	200	-

Increased   Decreased

Based on the previous discussion, the conditions under which collaboration with competitors: co-opetition works effectively are assumed to be as follows.

1. Market: A mature market with a limited market size (pie)
2. Customer needs: Proposals for complex systems are required
3. Player: A company with high collaborative capability like Hitachi

Zosen

4.6 Summary of this Chapter

In this chapter, we analysed how construction firms' organisational capabilities evolved through their participation in PPP/PFI projects to provide open and service innovation. While some studies focused on the capability development of construction firms through PPP/PFI arrangements, most of them conducted short-term and project-based analyses. Therefore, in the business ecosystem, there is still little understanding of the long-term dynamics of a project-based firm's evolution of capabilities and the influence of its partner companies.

In this chapter, three cases (Hitachizosen, Takuma and Ebara) were analysed through the view of three organisational capabilities: technological capability, project capability and collaborative capability. This research suggests the measurement of the shift of these organisational capabilities and the mechanisms behind this capability development.

Our results highlighted the collaborative capability could be a key factor for construction firms to expand their service field. We also discussed the mechanisms behind how collaborative capability affects construction firms' organisational capabilities by answering the R.Q.2. 'Co-opetition' would be a key concept to explain the mechanisms.

Chapter 5 Conclusion and Implication

5.1 Introduction

This dissertation aimed to reveal how Japanese construction firms have improved their organisational capability under the strategy to provide a broader range of services by expanding their cooperation with various other firms under the PPP/PFI procurement arrangement.

In Japan, since the establishment of the PFI Act in 1999, PPP and PFI have been developed to improve public service standards, reduce public burdens, and create new private business opportunities. Public works are promoted under the framework by the government, and about 740 PPP/PFI projects have already been implemented. Through PPP/PFI, private enterprises are expected to improve public service standards through the ingenuity and innovation of private businesses by expanding their involvement in the provision of public services, including financing and management.

However, research on the effects of existing PPP/PFI projects mainly focuses on the evaluation of the project itself, and whether it is effective for providing public services depends on the project.

There are several studies in the Europe (especially in the UK) that focus on the organisational capacity development of construction companies or project-based companies towards service innovation, but most of these studies are short-term and project-based analysis (For example, the London Heathrow Terminal 5 Project and the London Olympics), and the long-term dynamics in the organisational capabilities of the construction company itself are still poorly understood.

The study was aimed at filling the aforementioned knowledge gaps by addressing the following questions:

R.Q.1: How have construction firms' organisational capability evolved to provide PPP/PFI services for the public sector?

R.Q.2: Why do construction firms' organisational capabilities evolve through PPP/PFI arrangements under their strategy?

To answer these research questions, integrated qualitative and quantitative approaches were used. Based on Eisenhardt's approach, we analysed three plant engineering companies that conduct waste management PPP/PFI projects: Hitachizosen, Ebara and Takuma (Martin and Eisenhard 2010, Tsoumada 2021). To analyse the evolution of their organisational capabilities, several indicators were introduced. As part of the quantitative analysis, we developed an original PPP/PFI project database based on the results of 1,437 bids for PPP/PFI projects. The bidding information included contract-based project details, the list of member companies and their roles, the results of evaluations by a selection committee and a summary of the proposals. Also, data such as patent data, R&D expenses and sales and profit of the focal companies were collected. As part of the qualitative analysis, interviews with ten experts from plant engineering companies, municipalities and waste management associations were conducted.

The three firms were analysed from the view of accumulation of three organisational capabilities – technological capability, project capability and collaborative capability – as well as their performance.

5.2 Findings

In this dissertation, we proposed a model of capability development towards service and open innovation consisting of three particular organisational capabilities: technological capabilities, project capabilities and collaborative capabilities in the case of a construction firm which is a key factor in PPP/PFI. The model can be seen as ideal for understanding and comparing cases of long-term capability accumulation of project-based firms, especially with regard to providing services that meet the public's needs.

R.Q.1: How have construction firms' project and technological capability evolved to provide PPP/PFI services for the public sector?

Table 5.1 summarises the three focal firms' evolution of organisational capability through PPP/PFI arrangement.

In terms of performance, Hitachizosen and Takuma witnessed a positive impact after participating in PPP/PFI projects unlike Ebara, which witnessed a dramatic decrease in their related sales. This difference would be related to the evolution of organisational capability through PPP/PFI arrangement

As Table 5.1 shows, the number of patent registrations related to solid waste treatment technology significantly decreased after 2002. Moreover, the cumulative number of patent registrations (1996–2020) is not much different between the three target companies, implying that participation in and execution of PPP/PFI projects is not directly related to the number of registered patents.

Project capability, in contrast, shows a clear difference between the three companies, especially in Phase 4 (2017–2021). Hitachizosen and Takuma's success rates increased significantly over the period, reaching 82% and 84%, respectively, while EBARA's success rate was only 64%. One of these major factors could account for the difference in collaborative capability with external actors.

Hitachizosen actively collaborated with many external actors and sometimes with competing plant manufacturers such as Kyokuto Kaihatsu and ShinMaywa. Although Takuma is collaborated limited number of external actors, it also collaborated with external actors and actively promoted collaboration with their competitors and group companies. On the other hand, Ebara largely executed the projects within the company. During the analysis period, its cooperation with external actors and competitors decreased.

These differences in collaboration capabilities exerted a significant impact on the differences in performance between Hitachizosen, Takuma, and Ebara, and the interviews with plant engineering companies and a waste management association revealed the importance of collaborative capability.

Table 5.1: Evolution of organisational capability through PPP/PFI arrangement

Categories		Hitachizosen	Ebara	Takuma
Case description		Established in 1881 as a shipbuilding company Current main business is on environments and plants	Established in 1912 as a pump manufacturer Current main business is wind and hydro power facilities	Established in 1938 as a boiler manufacturer Current major products include boilers and mechanical equipment
Performance	Sales	Positive (CAGR: 5.5%)	Negative (CAGR: -5.7%)	Positive (CAGR: 6.2%)
	Profit	Positive	Positive	Positive
Technological capability	Patent registration (Single fiscal year)	Decreased (35 in 1996 -> 0 in 2020)	Decreased (16 in 1996 -> 1 in 2020)	Decreased (22 in 1996 -> 3 in 2020)
	R&D expenses	Slightly increased (1.7B in 1996 -> 2.2B in 2020)	Decreased (5.7B in 1996 -> 0.7B in 2020)	Slightly decreased (1.0B in 1996 -> 0.9B in 2020)
Project capability	Number of executed PPP/PFI projects	30 projects	20 projects	19 projects
	Success rate of PPP/PFI bids	Success rate in Phase 4 (2017-2021): 82%	Success rate in Phase 4 (2017–2021): 64%	Success rate in Phase 4 (2017-2021): 88%
Collaborative capability	Number of member firms in a consortium	Collaborated with many external actors (average 5.0 companies)	Collaborated with limited external actors (average 3.3 companies)	Collaborated with limited external actors (average 3.8 companies)
	Collaboration with competitors	Collaborated with potential competitors in 6 projects	Limited collaboration with potential competitors (only one project)	Collaborated with potential competitors in 3 projects

R.Q.2: Why do construction firms' organisational capabilities evolve through PPP/PFI arrangements under their strategy?

Collaborative capability can facilitate the accumulation of further project capabilities. PPP/PFI arrangements foster collaborations with partner companies, such as local construction and civil engineering companies. Moreover, since the field of civil works is highly standardised, it is relatively easy to build collaborative relationships, and there is an abundance of companies to choose from. Hitachizosen, after they learned and managed project management and construction of the incinerator plant – the core services of waste management PPP/PFI projects – collaborated with other companies for all other services such as operation and maintenance of incinerator plant and construction of recycling plant [46].

The study findings highlight that collaborative capability could be a key factor for construction firms in expanding their service field. Since Japanese construction firms traditionally have a strong relationship with other companies in the same business field, it would be relatively easy to build collaborative relationships.

5.3 Contribution

5.3.1 Contribution to Theories

5.3.1.1 Evolution of organisational capabilities under the PPP/PFI arrangement

This study focused on the long-term evolution of the organisational capabilities of construction companies, a topic that had not received any academic attention so far, with representative companies of PPP/PFI, such as Hitachizosen, Takuma and Ebara.

The following are this study's contributions to theories:

[46] In regard to ash recycling treatment, Hitachizosen did not manage by themselves before collaboration. However, the business scheme of ash recycling is separate from waste treatment incineration facilities.

This study investigated the strategic differences of a construction company's three types of organisational capabilities under the PPP/PFI arrangement: technological capability, project capability and collaborative capability. It also suggested indicators and developed an original database of PPP/PFI projects to measure the evolution of the indicators of organisational capability. The cases were structurally analysed for the three capabilities and strategy.

As per the study findings, although Hitachizosen was a latecomer to PPP/PFI projects compared to other companies, their project capability improved significantly. This is because Hitachizosen improved their technical proposal capability by building a company-wide, proposal-making structure centred on the design department. This finding contradicts the theory that Davies and Brady (2000) advocated about the learning curve, that the more the number of projects taken on by a company, the more the company can benefit from the "scale of repetition" and gain a competitive advantage. As shown in this study, it is not just a matter of the number of projects. To secure a long-term competitive advantage, how much a company focuses on waste-to-energy PPP/PFI projects and builds an organisational structure that can work well for both high-quality and low-priced proposals is equally important.

This study also presented the strategic differences between construction companies' developments for collaborative capability by exploiting opportunities under the PPP/PFI arrangement. In a previous study of the organisational capabilities of construction companies (Gann and Salter, 2000), collaboration with external companies through construction projects was considered only as suppliers and technical partners. On the other hand, in PPP/PFI projects, to provide effective services, it is necessary to collaborate with external companies in a long-term business-partner relationship for about 15 to 20 years.

5.3.1.2 Co-opetition: collaboration with competitors

Despite of the increasing importance of concept of co-opetition (Gnyawali and Park, 2011; Walley 2007), it has not been adequately examined, especially in the field of project-based organisations such as construction firms.

According to the analysis results of this study, Hitachi Zosen and Takuma, which accumulated capability to collaborate with competitors, showed higher performance than Ebara. In this research, we discuss the mechanisms behind their co-opetition strategy.

Based on our discussion, the conditions under which collaboration with competitors: co-opetition works effectively are assumed to be as follows.

1. Market: A mature market with a limited market size (pie)
2. Customer needs: Proposals for complex systems are required
3. Player: A company with high collaborative capability like Hitachi Zosen

5.3.2 Contribution to Construction Firms' Management

First, the results highlight that collaboration with competitors in the field of PPP/PFI projects would be a key factor for construction firms to expand their service field. Japanese construction firms traditionally have a strong relationship with other companies in the same business, so it would be relatively easy to build collaborative relationships. Although the PPP/PFI arrangement encourages construction firms to provide a wider range of services, collaboration with competitors is still limited. In this context, our study shows that competing with the higher management ability of competition are important for ensuring high performance. Collaboration with competitors, as the results show, had a positive impact on firm performance, at least in the context of waste PPP.

Second, the study proposed a model of the dynamics of capability development towards service and open innovation consisting of three particular organisational capabilities: technological capabilities, project capabilities and collaborative capabilities in the case of construction firms, which is a key factor in the waste-to-energy PPP/PFI project. The model can be considered ideal for understanding and comparing cases of long-term capability accumulation of project-based firms, especially regarding providing services that meet the public's needs (see Figure 5.1 - 5.3). Before PPP/PFI (-2002), construction company accumulated technological capability in order to build plant facilities. In Phase 1-3 (2002-2017), construction company accumulated project capability and collaborative capability in order to provide in PPP/PFI service for 15 years. In Phase 4 (2017-2021), collaborative capability accumulated by the collaboration with competitors would be a key capability and it provides further project and technological capabilities accumulation.

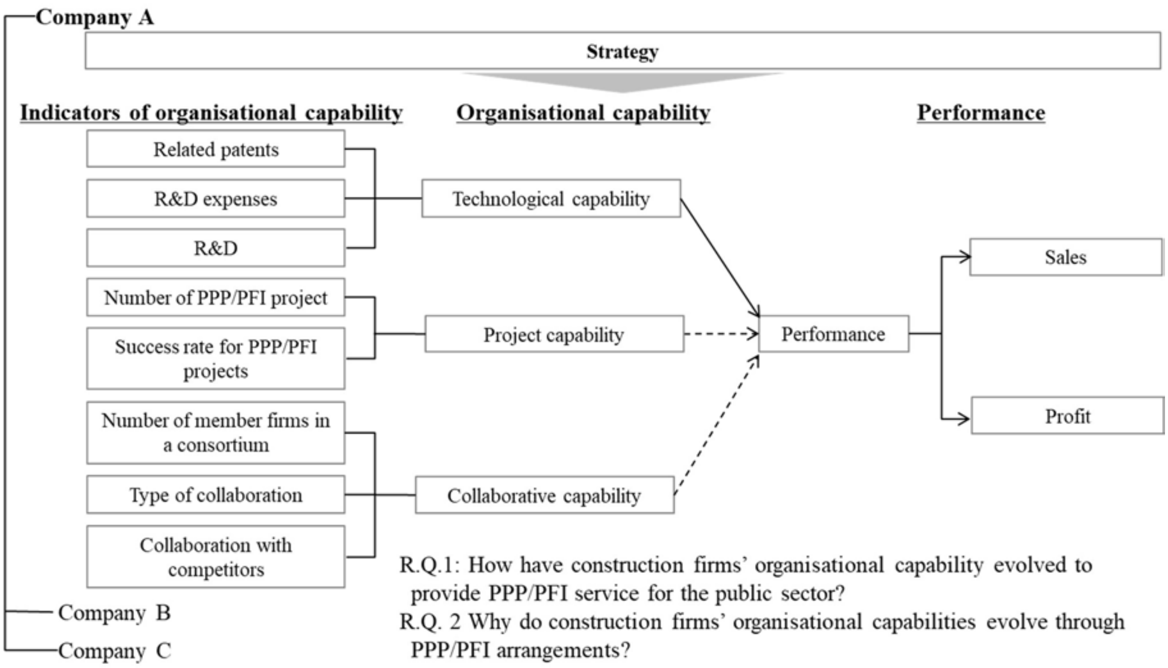

Figure 5.1: Dynamics of capability development of PPP/PFI arrangement: Before PPP/PFI (-2002)

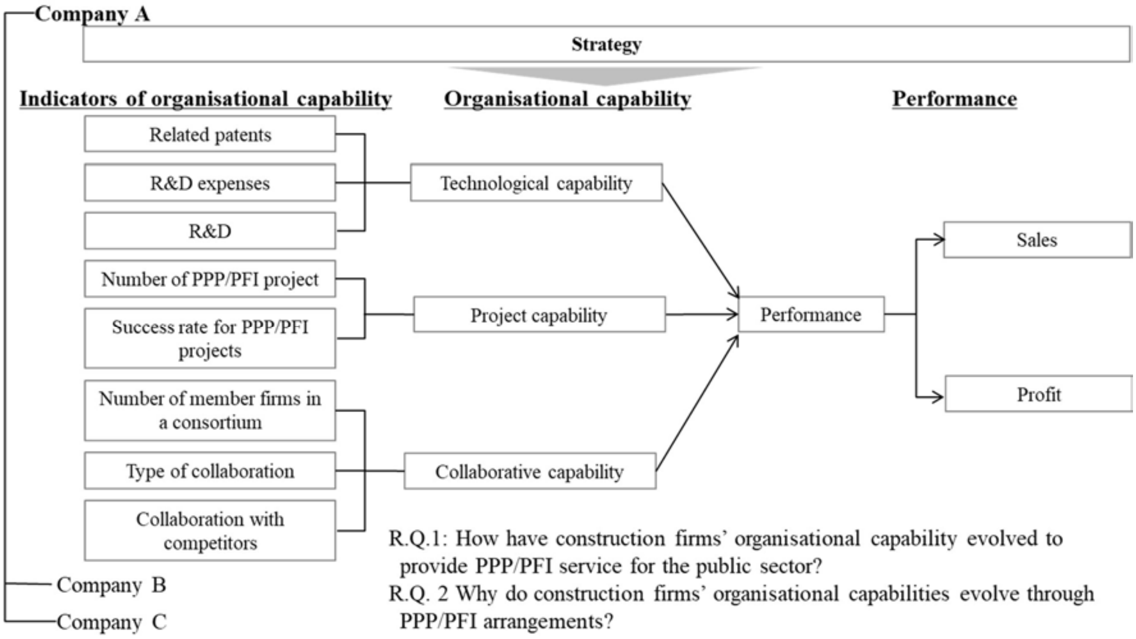

Figure 5.2: Dynamics of capability development of PPP/PFI arrangement: Phase 1-3 (2002-2017)

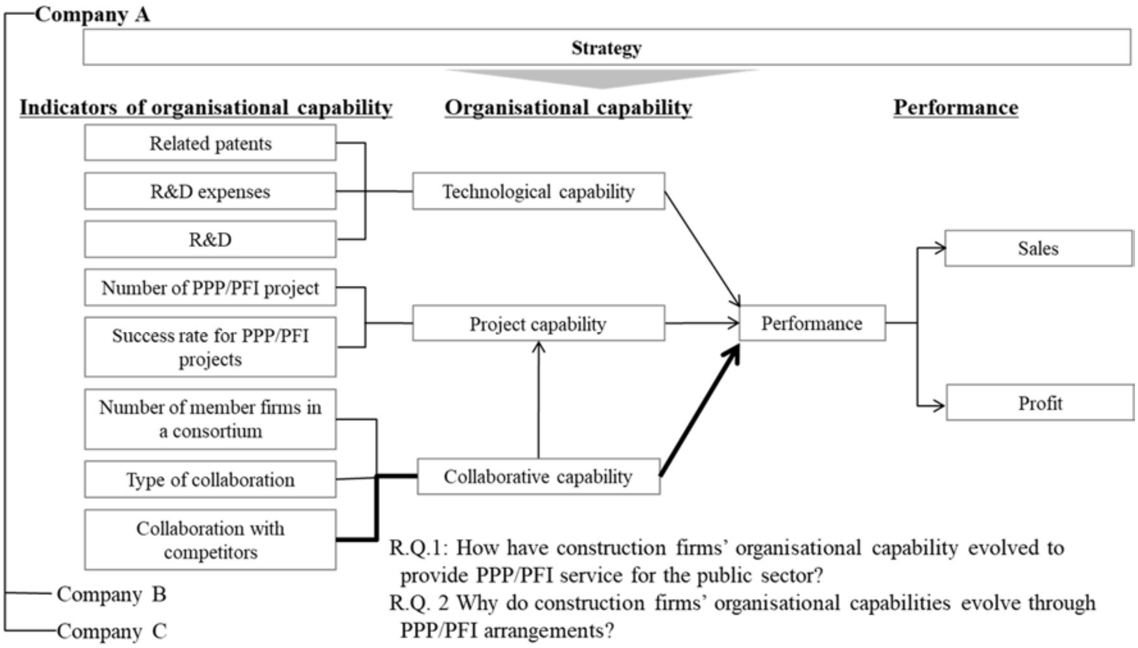

Figure 5.3: Dynamics of capability development of PPP/PFI arrangement: Phase 4 (2017-2021)

Third, when we consider the current PPP/PFI market in Japan, there are, compared to 20 years ago, several diverse types of projects. The number of

O&M-oriented concession projects (e.g. airport, road, water and sewage) is increasing rather than construction-oriented projects (e.g. waste-to-energy, government office and public housing). Also, not only the PPP/PFI but also the business field of construction firms is also becoming wider, such as renewable energy development, commercial complex development, operation and maintenance of complex facilities (e.g. hospitals) and energy management of facilities. To capture opportunities in this new market, from the perspective of long-term strategy, exploration other companies technological and project capabilities through appropriate collaboration with companies outside of the current eco-system would be necessary for Japanese construction firms.

5.4 Limitations and Future Research

This study aimed to reveal how Japanese construction firms have improved their organisational capability to provide a broader range of services by expanding their cooperation with various other firms under the PPP/PFI procurement arrangement. To this end, we proposed indicators, and we clarified why the accumulation of organisational capability leads to improved firm performance.

This study had several limitations.

First, since this study targeted PPP/PFI in Japan, it is unknown to what extent the theory of organisational capability can be applied to other fields or countries. In the case of other countries, the procurement method of PPP/PFI projects and the business model of the SPVs (mainly construction companies) may be different. However, the theory may be applicable in the context of organisational capabilities in project-based companies and CoPS, such as the equipment industry and aircraft industry, which, since they have not been studied much so far, could be taken up by future research.

Second, since this study focused on the capability development of construction firms, there is lack of the view from the governments for the PPP/PFI evaluation. Thus, future research from the view of PPP/PFI evaluation from the government (public sector) would help to fully understand the influence of PPP/PFI arrangement. Also, although this study found the accumulation of capability development of construction firms under the PPP/PFI arrangement, it is considered that there is room for improvement in the PPP/PFI arrangement so that it can contribute to improving the capabilities of private companies such as construction companies. The future research of comprehensive evaluation of PPP/PFI might be interesting if they include the suggestion to improve the PPP/PFI arrangement such as the procurement method of PPP/PFI projects and business model of the SPVs.

Conflict of Interest

The author declares that: (i) no support, financial or otherwise, has been received from any organisation that may have an interest in the submitted work; and (ii) there are no other relationships or activities that could appear to have influenced the submitted work.

References

Arthur Andersen, and Enterprise LSE (2000) ‘Value for Money Drivers in the Private Finance Initiative’, London: U.K. Treasury Taskforce

Bell, M. (2009) ‘Innovation Capabilities and Directions of Development’, STEPS Working Paper 33, Brighton: STEPS Centre

Bengtsson, M., Kock, S., (1999) ‘Cooperation and competition in relationships between competitors in business networks’, Journal of Business and Industrial Marketing vol. 14, no.3, pp. 178‑190.

Brady, T., Davies, A., and Gann, D. M. (2005) 'Can integrated solutions business models work in construction?', Building research & information, vol. 33, No. 6, pp. 571–579

Brady, T., and Davies, A. (2004) 'Building project capabilities: from exploratory to exploitative learning' Organizational Studies, vol. 26, No.9, pp. 1601–1621.

Brady, T., Davies, A., and Gann, D. M. (2005a) 'Can integrated solutions business models work in construction?', Building research & information, vol. 33, No. 6, pp. 571–579

Brady, T., Davies, A., and Gann, D. M. (2005b) 'Creating value by delivering integrated solutions', International Journal of Project Management, vol. 23, pp. 360–365

Blayse, A. M. and Manley, K. (2004), 'Key influences on construction innovation', Construction Innovation, Vol. 4 ISS 3, pp. 143-154

Boardman, Anthony, Finn Poschmann, and Aidan Vining (2005) ‘North American Infrastructure P3s: Examples and Lessons Learned. In The Challenge of Public – Private Partnerships: Learning from International Experience’, edited by Graeme Hodge and Carsten Greve, 162 – 89. Cheltenham, UK Edward Elgar

Davies, A. and Brady, T. (2000) 'Organisational capabilities and learning in complex product systems: towards repeatable solutions' Research Policy, vol. 29, pp. 931–953

Davies, A. and Brady, T. (2016) 'Explicating the dynamics of project capabilities', International Journal of Project Management, vol. 34, pp. 314-327

Davies, A., Dodgson, M. and Brady, T. (2016) 'Dynamic Capabilities in Complex Projects: The Case of London Heathrow Terminal 5', Project Management journal, vol. 47, Issue 2, pp. 26-46

Djellala, F., Gallouja, F., Miles, I. (2013) 'Two decades of research on innovation in services: Which place for public services? ', Structural Change and Economic Dynamics, vol. 27, pp. 98-117

Dutrenit, G., (2000) 'Learning and knowledge management in the firm. From knowledge accumulation to strategic capabilities', Cheltenham: Edward Elgar.

Elder, J. and Georghiou, L. (2007) 'Public procurement and innovation—Resurrecting the demand side', Research Policy, vol. 36, pp. 949-963

Erridge, A., Nondi, R. (1994) 'Public procurement, competition and partnership', European Journal of Purchasing & Supply Management, vol. 1, No. 3, pp.169–179al

European PPP Expertise Centre (2010) Procurement of PPP and the use of Competitive Dialogue in Europe - A review of public sector practices across the EU [online], Available from: https://www.eib.org/attachments/epec/epec_procurement_ppp_competitive_dialogue_en.pdf (Accessed: 27 September 2019)

Gallouja, F., Weinstein, O. (1997) 'Innovationin services', Research Policy, vol. 26, pp. 536-556

Gann, D. M. and Salter, A. J. (2000) 'Innovation in project-based, service-enhanced firms: the construction of complex products and systems' Research Policy, vol. 29, pp. 955–972.

Geroski, P. (1990) Procurement policy as a tool of industrial policy, International review of applied economics, vol. 4 (2), pp. 182–198

Gnyawali, D.R., Park, B.J., (2009) 'Co-opetition and technological innovation in small and medium-sized enterprises: amultilevel conceptual model', Journal of Small Business Management 47 (3), pp. 308–330.

Grabher, G. and Thiel, J. (2015) 'Projects, people, professions: Trajectories of learning through a mega-event (the London 2012 case)', Geoforum, vol. 65, pp. 328-337

Hall, John (1998) ‘Private Opportunity’, Public Benefit, Fiscal Studies, vol.19, no. 2, pp. 11-40

Hamamatsu City Environment Department (2018) Hamamatsu New Waste-to-energy and Recycling PFI Project Procedure [in Japanese], Available from: https://www.city.hamamatsu.shizuoka.jp/shori/shinseiso/pfi.html (Accessed: 6 June 2019)

Hodge, G. A. and Greve, C. (2007) 'Public–Private Partnerships: An International Performance Review', Public Administration Review, vol. 67, pp. 545-558

Japan, Cabinet Office (2013) Action plan for drastic reform of PPP/PFI [in Japanese], Available from: https://www8.cao.go.jp/pfi/whatsnew/kiji/actionplan.html (Accessed: 30 April 2019)

Japan, Cabinet Office (2014) Current situation of PFI [in Japanese], Available from: http://www8.cao.go.jp/pfi/pfi_genjyou.pdf (Accessed: 20 May 2018)

Japan, Cabinet Office (2015) Guideline for prioritizing the introduction of various PPP / PFI arrangement [in Japanese], Available from: https://www8.cao.go.jp/pfi/yuusenkentou/gaiyou/gaiyou.html (Accessed: 30 April 2019)

Japan, Cabinet Office (2018) Promotion of PFI [in Japanese], Available from: http://www.mlit.go.jp/common/001147421.pdf (Accessed: 6 June 2019)

Japan, Ministry of Environment (2013) Guide to creating order specifications for waste treatment facilities (Standard order specifications and explanation) Energy recovery promotion facility [in Japanese], Available from: http://www.env.go.jp/recycle/waste/3r_network/7_misc/man_wtfspec/1-1_hrf.pdf (Accessed: 6 June 2019)

Martin Bell & Paulo N. Figueiredo (2012) 'Innovation capability building and learning mechanisms in latecomer firms: recent empirical contributions and implications for research', Canadian Journal of Development Studies/Revue canadienne d'études du développement, vol. 33, No.1, pp. 14-40

Nagoya city Environment department (2013) Narumi waste-to-energy plant [in Japanese], Available from: http://www.city.nagoya.jp/kurashi/category/19-14-2-2-0-0-0-0-0-0.html (Accessed: 6 June 2019)

Narumi clean system Co., Ltd. (2019) Nagoya city Narumi waste-to-energy plant construction and operation project [in Japanese], Available from: http://www.narumi-cs.com/index.html (Accessed: 6 June 2019)

Nippon Steel & Sumikin Engineering (2014) Waste treatment & recycling plants, Available from: http://www.eng.nssmc.com/english/business/environment/e_01 (Accessed: 6 July 2014)

Ritala, P., Hurmelinna-Laukkanen, P., Blomqvist, K., (2009) 'Tug of war in innovation−coopetitive service development', International Journal of Services, Technology and Management vol. 12, no. 3, pp. 255‑272.

Robinson, H. Carillo, P., Anumba, C. J. and Patel, M. (2010) Governance & knowledge management for Public-Private Partnerships, John Wiley & Sons Ltd: West Sussex

Savas, E. S. (2000) Public-private partnerships, Seven Bridge Press, LLC: New York

Suehiro, T. and Miyazaki, K. (2018) 'The Evolution of Construction Firms' Organisational Capability towards Open and Service Innovation through PPP/PFI in Japan- Towards Efficient Operation Based on ICT Technology' 17th International Schumpeter Society Conference, July 2-4, Seoul

The United Kingdom, House of Commons, Treasury Committee (2011) Private Finance Initiative, Seventeenth report of session 2010-12, London: The stationery Office Limited

The United Kingdom, National Audit Office (2018) PFI and PF2 [Online], Available from: https://www.nao.org.uk/wp-content/uploads/2018/01/PFI-and-PF2.pdf (Accessed: 30 April 2019)

The United Kingdom, HM Treasury (2012) A new approach to public private partnerships [Online], Available from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/205112/pf2_infrastructure_new_approach_to_public_private_parnerships_051212.pdf (Accessed: 10 April 2018)

The United Kingdom, Office of Government Commerce (2004) 'Capturing Innovation: Nurturing Suppliers' Ideas in the Public Sector', [Online], Available from: https://webarchive.nationalarchives.gov.uk/20100407164828/http://www.ogc.gov.uk/documents/capturing_innovation.pdf (Accessed: 10 April 2018)

The United Kingdom, National Audit Office (2007) Improving the PFI tendering process, [Online], Available from: https://www.nao.org.uk/wp-content/uploads/2007/03/0607149.pdf (Accessed: 5 May 2019)

The United Kingdom, HM Treasury (2012) A new approach to public private partnerships [Online], Available from:https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/205112/pf2_infrastructure_new_approach_to_public_private_parnerships_051212.pdf (Accessed: 10 April 2018)

The United Kingdom, National Audit Office (2018) PFI and PF2 [Online], Available from: https://www.nao.org.uk/wp-content/uploads/2018/01/PFI-and-PF2.pdf (Accessed: 30 April 2019)

The United Kingdom, National Audit Office (2003) PFI: Construction Performance .London: Her Majesty's Stationery Office. HC 371

Uyarra, E., Edler, J., Garcia-Estevez, J., Georghiou, L. and Yeow, J. (2014) 'Barriers to innovation through public p. Techonovation

Walley, K., (2007) ‘Coopetition: an introduction to the subject and an agenda for research’, International Studies of Management & Organization, vol. 37, no. 2, pp. 11‑31.

Worsnop, T., Miraglia, S., and Davues, A. (2016) ‘Balancing open and closed innovation in megaprojects: insights from Crossrail’, Project Management Journal, vol. 47, issue 4, pp.79-94

Zerjav, V., Edkins, A. and Davies, A. (2018) 'Project capabilities for operational outcomes in inter-organisational settings: The case of London Heathrow Terminal 2', International Journal of Project Management, vol. 36, pp. 444-459