



# Diversification and Railway Business Strategies of Japanese Private Railway Companies: An Empirical Analysis of Efficiency and Investment Policy

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(Degree)

博士 (経営学)

(Date of Degree)

2016-03-25

(Date of Publication)

2018-03-25

(Resource Type)

doctoral thesis

(Report Number)

甲第6598号

(URL)

<https://hdl.handle.net/20.500.14094/D1006598>

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博士論文

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Business Strategies of  
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Analysis of Efficiency and  
Investment Policy**

2016年 1月 18日

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# 1. Introduction

## Background and Purpose of the Research

In most industrialised countries, governments have supplied public transportation services and are responsible for supervising and managing their quantity and/or quality in present. However, the issue of efficiency in the transportation system has recently come into question. Public ownership, subsidies, operating deficits, and inefficient operation are the main issues of debate on urban transportation.

*Table 1.1 The ratio of fares to operating costs for public transit system*

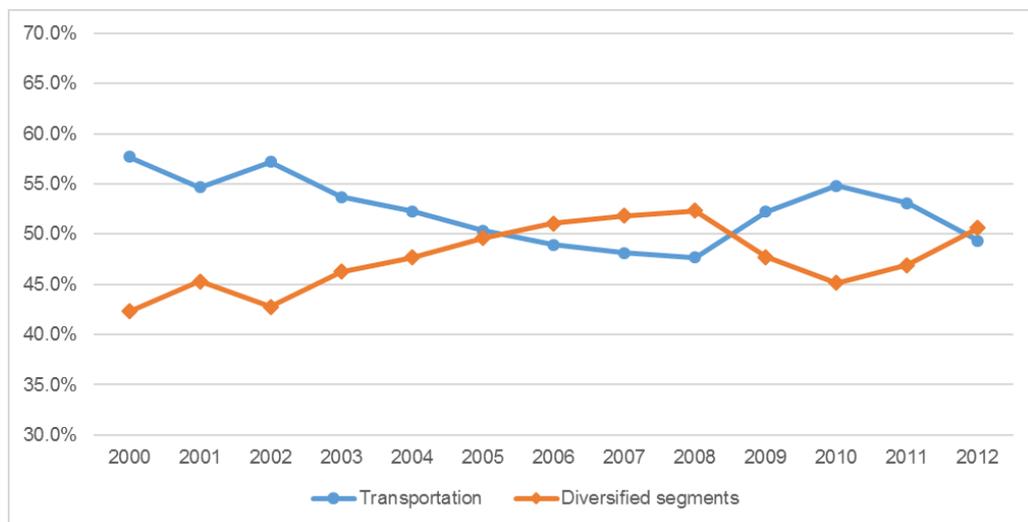
Country	System	Farebox ratio (%)	Year
Hong-Kong	MTR	186	2012
Taiwan	MRT (Taipei)	119	2012
Singapore	SMRT	134	2012
U.K.	London underground	92	2012
France	RATP (Paris)	96	2012
Finland	HSL (Helsinki)	62	2012
U.S.	CTA (Chicago)	61	2013
Japan	Hankyu railway (Osaka)	146	2010
Japan	Tokyu railway (Tokyo)	145	2010

Source: Annual report and financial report of each operator, Suji de Miru Tetsudo (2011)  
(The original source was adapted for purposes of the study.)

Especially, many industrialised countries are suffering from operating deficit, which is that operating revenue cannot cover the operating costs. Table 1.1 presents the farebox ratio, which is the ratio of operating costs to fare revenues, of public transit in major cities of the world. As described in Table 1.1, most of the systems cannot cover their operating expenses by its fare revenues, except for the two Japanese companies and the systems operated in the high-density populated urban area. Although the farebox ratio is not highly confident measure considering differences in accounting rule, subsidising system, details of operating revenue and accounting system for deficit of each country, it can be regarded as an indicator which provides background to understand the overall circumstance around the urban railway system of each city (Shoji, 2001).

On the other hands, one of the most popular topics in public transport is using

private sector operations such as franchising and competitive tendering to overcome the low profitability and operational inefficiency of public transport discussed above (Yvrande-Billon, 2006; Hensher & Stanley, 2008). In fact, passenger transportation services operated by the private sector were a general form of provision during the ‘railway boom’ that begun in Europe, Japan, and North America at the turn of the 20th century and led to the establishment of many private railway companies (PRCs hereafter). However, while numerous such PRCs went bankrupt because of financial difficulties, PRCs in Japan survived by operating profit-making passenger railways in urban areas. Further, most PRCs in Japan are now also engaged in sectors such as real estate, distribution (retail), and other transportation mode (taxis and buses) in addition to their core railway business. While the success of PRCs is driven by densely populated urban areas and mass prepaid commuter passengers (Killeen, 1999), difficulty in raising railway fares and demand decreases due to the decline in the productive age population are threatening the operation of PRCs.



*Figure 1.1 Change in the ratio of the operating profit of the transportation segments and diversified segments of major PRCs in Japan (Year means)*

Nevertheless, as private enterprises, PRCs make their own business portfolio, such as diversification and investment decisions, and compete with other companies in some routes based on the market principle (Shoji, 2001). Further, the implementation of a diversification strategy is a unique feature of PRCs in Japan compared with those in other countries. Thus far, the diversification strategies of

PRCs in Japan have generally been considered to be motivated and deployed in order to support the railway business. However, the operating profit of diversified segments has been higher than those generated by railways and related businesses in some companies. Figure 1.1 illustrates the change in the ratio of the operating profit of the transportation segments and diversified segments to the total sales of major PRCs in Japan from 2000 to 2012. This figure shows that the ratio of the total operating profit of diversified segments to the total sales tended to increase compared with that of transportation segments. Some PRCs even announce expansions to the scale and extent of their diversified business in their annual reports or mid- or long-term management strategies, thereby emphasising the importance of diversification. In other words, diversification may no longer be considered to support the railway business, but rather be an essential business strategy for the sustainability of PRCs.

Although diversification strategies seem to act importantly in PRCs, most previous research focuses on categorising the type of diversification and its relationship between diversification strategies and PRC's performance quantitatively. In addition, it has not been investigated how they influence the railway business in terms of internal capital resource allocation for investment, focusing on the coexistence of railways, which are considered as to be public utilities, and diversified businesses. Previous research has noted the diversification strategies of Japanese PRCs, and investigated their effects, focusing on their contribution to the profitability of the railway business and to the entire company. However, most previous studies focus on the relation between diversification and performance at the firm-level; finding research on how diversification strategies influence performance in terms of a firm's strategic efficiency and investment in the railway business for acquiring and upgrading assets is more challenging. Based on the foregoing, the purpose of this research is to clarify the factors influencing a firm's performance, focusing on the technical efficiency and to investigate how the mechanism of internal capital allocation is worked in major PRCs focusing on the influence on railway business. In order to scrutinise the relationship between diversification strategies and a firm's efficiency, and effect on railway business, two different empirical analyses are

performed using data of Japanese PRCs. Based on the review of previous research and the results of empirical analysis, this study aims to provide implication for private operators and authorities which consider introduction of private operation to public transport, and to contribute to designing innovate business model of operation of railway business which balance public interest and pursuit for profit and growth of the firm.

### **Organisation of the Research**

The structure of the remainder of this dissertation is as follows. First, the previous research of diversification strategies in strategic management and industrial organisation is reviewed in chapter 2. Then, this study delineates railway system and business strategies of Japanese PRCs and introduces previous research on diversification strategies of Japanese PRCs in chapter 3. In chapter 4 and 5, diversification strategies of PRCs are analysed in perspective on technical efficiency. Before estimating production function of PRCs, chapter 4 provides theoretical explanation of production function and stochastic frontier analysis. In chapter 5, empirical analysis of diversification strategies and a firm's efficiency is conducted and implication and conclusion are derived. Next, the effect of diversification on investment in railway companies is quantified using regression model and the result from estimation is discussed in chapter 6. Finally, summary, finding and implications of this dissertation are provided and further research questions are suggested in chapter 7.

## **2. Overview of Diversification Strategies**

Diversification can be described by the extent of participation in different businesses and the underlying relationships between the various businesses within each firm (Nayyar, 1992). It can be also explained as the set of strategies that consists of choosing the types of businesses the firm will enter, the extent of which the firm will rely on past competencies or require the development of new ones, and the total amount of diversity considered as appropriate in favour of a single strategy (Rumelt, 1974).

Literature on diversification has covered a wide range of research questions and issues within its broad scope. In this chapter, this study examines three major topics of diversification research: 1) motivation of diversification 2) type of diversification strategies, and 3) relationship between diversification strategies and the firm's performance based on the previous research of strategic management and industrial organisation.

### **Motivation of Diversification Strategies**

With regard to the motivation for diversification, Ansoff (1957) argues that a firm wants to be compensated for the deterioration of current technology, to diffuse risk, to utilise excess production capacity, to reinvest revenue, and to acquire superb operation abilities. Porter (1980) mentions the effect of cost reduction through accumulation of experience. He discusses that the cost reduction is amplified when the firm utilises its experience in the process of creating a new product which is similar to a firm's current product, or when it fully utilises accumulated experience to other related business. In other words, the firm considers diversifying because it can lighten the burden of additional cost by sharing common factors, such as experience acquired from the operating business in the present for a new, highly similar one. Based on these arguments, Montgomery (1994) synthesises the three views of the motivation for the firm's diversification followings, which are the market-power view, agency view, and resource view (see also Montgomery (1994)).

First, market-power view focuses on building conglomerate power in the market through diversification strategies. Diversified firms (or conglomerates) build the power in anti-competitive ways which are cross subsidisation, mutual forbearance and reciprocal buying, and these practices hinder market competition and lead to higher industry concentration. This view tends to emphasise the results of diversification and observe a positive relationship between diversification strategies and firm performance.

On the other hand, agency view focuses on the effect of diversification strategies on firm value, rather than its profitability as performance, and is discussed by financial economists. In this view, life cycle of the firm and ownership structure of the firm are associated with motivation of diversification strategies. When core businesses of the firm generate plentiful cash to reinvest but matured and have scarce growth opportunity, managers are likely to use cash flows to pursue their own interests (Mueller, 1972). Absence of significant ownership stakes accelerates this tendency and managers utilise unused cash to diversify by investing in low-benefit or value-destroying mergers (Jensen, 1986). Especially, if managers have little equity in the firm and monitoring is not easy because of dispersion of shareholders, corporate assets may be used to benefit managers, rather than shareholders. Previous literature refers that value-decreasing diversification occur because of managers' behaviour, which emphasise their particular skills in diversifying and control employment risk (Amihud & Lev, 1981; Shleifer & Vishny, 1989). Therefore, agency view predicts a negative relationship between diversification strategies and firm value.

Finally, resource view assumes that a firm diversifies in response to excess capacity in productive factors, called resources. Resources include factors purchased in the market, services created from productive factors, and special knowledge accumulated by the firm. The resources are not homogeneous, but heterogeneous for each firm and they are reformed as the firm's asset and capabilities. Therefore, firm profitability and the extent of diversification strategies are related to the stock of the firm's assets, core competencies, and distinctive capabilities. Especially, if these resources are hard to be copied and be transferred by competitors, they can be

potentially a source of competitive advantages in the markets. Heterogeneity of each firm and existence of competitive advantages are important factors to explain the relationship between diversification strategies and performance in this view. Because firms have different capabilities and resources which contribute to competitive advantages, their optimal level of diversification is not same. Thus, the firm with resources which have less impact on building competitive advantages may diversify to relatively high level of diversification, while the firm with resources which have more impact on building competitive advantages could gain higher profits than their competitors with lower level of diversification (Montgomery & Wernerfelt, 1988).

### **Types of Diversification Strategies**

Types of diversification strategies are based on the relatedness among the various businesses of the firm. Wrigley (1970) suggests a basic concept and Rumelt (1974) modifies it to assess the extent of diversification and the nature of relatedness among the business of a diversified firm (Nayyar, 1992). He also categorises the type of diversification strategies into four categories that can each be broken down into subcategories, to arrive at a total of nine categories.

The four major categories defined by Rumelt (1974) are single, dominant, related and unrelated business, and all but the single business category can be further divided into subcategories. As a result, the nine categories are the following: 1) single, 2) dominant-vertical, 3) dominant-unrelated, 4) dominant-constrained, 5) dominant-linked, 6) related constrained, 7) related-linked, 8) unrelated, and 9) conglomerate. Each category is determined by the specialisation ratio (SR), related ratio (RR), and vertical ratio (VR), which are the ratios of operating profit for specialised, related, and vertical business as the followings (Rumelt, 1974):

- 1) Specialisation ratio: the proportion of a firm's revenues that can be attributed to its largest single business
- 2) Related ratio: the proportion of a firm's revenues attributable to its largest group of related businesses
- 3) Vertical ratio: the proportion of the firm's revenues that arise from all by-

products, intermediate products, and end products of a vertically integrated sequence of processing activities

The firm is likely to choose a type of diversification by considering the types of resources and tangible assets that it possesses. Intangible assets and financial resources are also considered important. Particularly, intangible assets from research activities like R&D are likely to be more connected with the related diversification (Chatterjee & Wernerfelt, 1991).

### Relationship between Diversification Strategies and Performance

Palich, Cardinal and Miller (2000) synthesise diversification-performance literature and suggest three points of view for the profitability issue. Figure 2.1 shows the three types of relationship between diversification and performance.

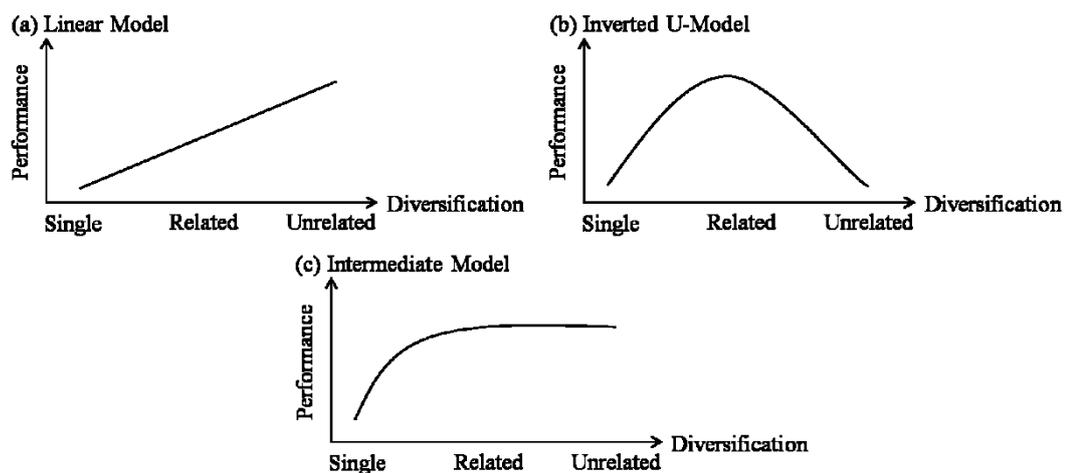


Figure 2.1 Models of diversification-performance linkage

Source: Palich, et al. (2000), pp. 157 (Figure 1)

Linear model assumes that the extent of diversification positively influences performance, thus, the more the firm diversifies, the higher the firm's performance. Market power view supports linear relationship and assumes that expanding diversification may yield increased profit by raising market share through reciprocal buying. However, there are few empirical works which support linear relationship based on the market power view (Palich, et al., 2000).

On the other hand, intermediate model presents a question about the difference in

performance between related firms and unrelated firms. Markides and Williamson (1994) argues that exaggerated relatedness resulting from simply exploiting resources and assets may not contribute to improvement of performance of the related firm. Nayyar (1992) also refers that potential benefits from relatedness is not easy to be realised because of lack of communication among divisions or subsidiaries and costly effort. Both arguments point out that some related business portfolios may not have any advantages over unrelated diversification due to difficulties exploiting relatedness, while unrelated diversification has an advantages of financial synergies by acquiring profitable businesses through takeovers and merger (Palich, et al., 2000).

While a negative aspect of diversification is emphasised in previous two models, resource view regards diversification strategies is a good way to increase profitability (Goddard, et al., 2008) and knowledge-based and inimitable resources can achieve the benefits of diversification (Miller, 2006). Rumelt (1982) also demonstrates through empirical analysis that related-constrained firms have the highest profitability among the diversification categories. Thus, the inverted-U model is strongly supported by many studies. It explains how a firm's performance improves as it diversifies to an appropriate level of related business, and it tends to decrease after a critical point (Bettis, 1981; Rumelt, 1982; Lubatkin & Chatterjee, 1994; Markides & Williamson, 1994; Robins & Wiersema, 1995; Palich, et al., 2000). It also explains how a firm's performance improves the more it diversifies, from the single business to related business of appropriate level of diversification. On the contrary, if a firm diversifies into unrelated business, its performance worsens gradually (Palich, et al., 2000). Therefore, properly matching a firm's resources or assets to its products or services may enhance its profitability. Regarding excellence of related firms in performance, Montgomery (1994) insists that industry concentration, profitability of industry and weighted average of the firm's market share drive better performance of related firms than that of other firms. In addition, Bettis (1981) argues that related firms outperforms the other firms because they exploits its core knowledge and advantages latent in technologies without huge additional costs. Related firms utilise not only possessing relevant resources or assets simply, but also underutilised assets,

thereby reaping economies of scope by sharing resources and combining activities along the value chain.

As discussed above, many previous studies support that related firms outperform other types of firms in performance, especially profitability, due to adequate diversification strategies. However, some studies also point out that diversification strategies influence strategic decision making at the business level due to complexity of the organisation and bureaucratic cost, whereby it affect the firm's performance indirectly (Stimpert & Duhaime, 1997). In other words, there are other factors which are possible to influence performance like industry membership and business strategy, as well as diversification strategies. For example, Prahalad and Bettis (1986) emphasise the role of 'dominant logic' of top management and define dominant logic as a mindset, a world view or conceptualisation of the business and the administrative tools to accomplish goals and make decisions in the business.

### **Diversification Strategies and Business Environment**

#### **(1) Research on diversification strategies of the service industry oriented firm**

Japanese PRCs mostly deploy urban public transportation, real estate, distribution (retail), leisure and consumer service (tourism, amusement park, theatre, hotel, restaurant, etc.), information and network, and cultural business, as well as manufacturing (rolling stocks) and construction business. Although PRCs cover most of businesses categorised into the service industry except manufacturing and construction businesses (Shoji, 2001), most issues on diversification strategies of previous section focuses on the firms engaging manufacturing businesses. Therefore, this study reviews the research on the diversification strategies of service firms, considering the difference between manufacturing and service business which are closed to diversification strategies of PRCs.

While some previous research agrees that service firms can benefit from economies of scope by sharing resources and assets of diversified businesses like manufacturing firms (Channon, 1979; Nayyar, 1993) and related firms also

outperform other firms in profitability (Channon, 1979; Nayyar, 1993; Normann, 2001; Capar & Kotabe, 2003), there is also evidence that diversification strategies which are deployed narrowly achieve superior performance in a sample of British service firms (Channon, 1979). For geographical diversification of service firms, Nayyar (1992) argues that geographically focused strategy effects on the firm's performance positively. Because services are intangible items required interaction between the firm and the customer, production and consumption of them occur simultaneously and are limited by location and time (Berthon, et al., 1999; Lovelock & Wright, 2002). The firms can also form intimacy with customers while they should undertake high investment for expansion of business (Capar & Kotabe, 2003). Thus, the firms can respond quickly and effectively with changes of the customers' needs and meet with their needs thoroughly by operating within a limited geographic region (Nayyar, 1992). Moreover, geographical diversification may prevent the firm from adapting to the customers' needs in limited areas. The firm should understand the cultural background of the new market and transmit information related to standardised rules from head office to subsidiaries to develop new products and services, as well as they should understand perfectly know-how and knowledge existing over a wide range of organisation of the firm. These processes require assimilation of extensive knowledge and need high cost and time.

Information asymmetry between the firm and the customer also influences on the diversification strategies of service firms and is generally considered as obstacles causing costs for the firms and the customers in exchange. However, a firm may achieve better performance by exploiting benefit from information asymmetry. Availability of information before purchase is more important in the case of services than that of other industries, because purchase of service mostly relies on the experience or credence qualities. Hence, the reputation is potentially a better solution to reduce information asymmetry than signalling for the high-quality service like high prices for potential customers, due to the possibility of distortion of signalling. As a result, when a firm diversifies into service businesses expected that existing customers may buy a firm's new service, it may create competitive advantages and

benefits exploiting the reputation formed by services having been provided by the firm so far because the customers tend to be reluctant to change service provider because of switching cost (Nayyar, 1990).

With regard to the measurement of diversification strategies of service firm, Nayyar (1992) investigates the relationship between relatedness and performance of large diversified U.S. service firms using two different measurements, which are based on internal data and externally available data separately. He argues that the measurement based on externally available data is likely to reflect potential relatedness, rather than actual relatedness which can be captured by internal data collected by questionnaire, because conflict inside organisation and absence of communication intervene realisation of relatedness. He also insists on the necessity of collecting data, enabling to understand the actual relatedness among businesses. Relatedness is one of the issues which should be considered thoroughly in case of the service firms. Rumelt's (1982) assumes for measures of relatedness that businesses must be related if a firm's businesses consist of similar products, markets or technologies and the measures are calculated using external examination of the product-markets in which the businesses participated, and a knowledge of key elements which relies on Standard Industrial Classification (SIC) code in U.S. companies. However, many researchers point out that SIC-based measures have critical limitations, not adequately reflecting the difference in each industry. Gassenheimer and Keep (1998) point out that using SIC classification may not be appropriate for assessing diversification in all economic sectors. They argue that the implications of diversification in manufacturing should be applied to non-manufacturing sectors under the careful consideration of the validity of previous research and additional information is needed. They also emphasize that the evidence supporting positive relationships between ROA and levels of related diversification is hard to find in non-manufacturing sectors.

## (2) Research on diversification strategies of public utilities

Public utilities regulated by the law have faced changes of deregulation and forced

to take strategic action to adapt changed circumstance like Japanese PRCs (Russo, 1992; McGuinness & Thomas, 1997; Jandik & Makhija, 2005). Regarding public utilities, the regulation can be considered as the factor influencing a firm's strategic choice like diversification strategies and vertical integration (Russo, 1992). Most of previous research on public utilities focuses on the case of post privatised companies and utilities whose core business is regulated.

Diversification strategies of electric utilities of the U.S. are closely associated with regulations and corresponding legislations. Especially, The Energy Policy Act of 1992 (EPACT) is a significant momentum of strategic changes to investor-owned electric utilities. They started its first step to business diversification in the early 1980 due to decreased rapid growth in electricity demand. Because of decrease in demand, many utilities reduce construction expenses and use extra cash flow to invest new businesses, rather than returning to investors as common dividends. Diversifying activities are strongly monitored and restricted by regulators to prevent them from unfair transaction, which is to buy supplies at an improper price and to make profits to upstream subsidiaries handsomely at the utility's expense, between parent companies and subsidiaries (Russo, 1992; Jandik & Makhija, 2005). Authorities (PUC: Public Utility Commissions) and utility ratepayers are sceptics about diversification of electric utilities, rather than expecting gains from synergies. From mid-80's, many PUCs responded by making the model legislation and developing detailed procedures to diversified electric utilities, although there was no state-level regulation in the early 80's. PUCs defined barrier between the utility and non-utility businesses to control diversifying activities of electric utilities. As a result, diversified non-utility businesses were separated from utility activities, thereby taking formation of isolated corporate subsidiaries. The PUC also regulated reciprocal transaction between the utility and non-utility subsidiaries and the proportion of the non-utility businesses (Jandik & Makhija, 2005). Although they mainly diversified into vertically integrated business and the sales of excess natural resources which are used to generate electricity until 1980, they expanded their activities outside core business such as insurance companies, telecommunications, and cable TVs through acquisitions and

takeovers (Jandik & Makhija, 2005; Yokoyama, 2007). They even moved into new lines of businesses which seem not to be related electricity business, such as leasing aircraft, acquiring insurance company, and buying a chain of drug stores and pharmaceutical subsidiary (Jandik & Makhija, 2005). However, after the enforcement of EPACT, electric utilities reached a turning point in their diversifying activities, which is to focus on the energy related business (Yokoyama, 2007) and to branch outside their traditional domain because unregulated entities are allowed to participate in generating and selling electricity at wholesale prices (Jandik & Makhija, 2005). They faced increased competition in the electric generating sector due to the deregulation which encourages the entry of independent power producers (Delmas & Tokat, 2005; Jandik & Makhija, 2005). At last, the transmission lines were opened in 1996 and regulators allowed retail deregulation initiatives in electric markets from 1998 (Delmas & Tokat, 2005). Mergers and acquisitions were observed in investor-owned electric utilities to enlarge scale and scope of business and increase power in competitive markets, mainly in the energy industry. As well as M&A activities, they have divested their non-core assets and reformed corporate structure focusing on the core business to reduce expenses by exiting from unrelated non-core businesses (Yokoyama, 2007).

Russo (1992) adopts a transaction cost economics perspective to investigate the relationship between regulatory monitoring and diversification strategies of American electric utilities and argues that monitoring effort of regulatory drives the firm to expand businesses which are not associated with regulation and facilitates externalisation to avoid high monitoring costs under unified governance. Jandik and Makhija (2005) suggest evidence that the degree of diversification is positively related to the excess value measures by preventing over investment in the electricity business and diversified utilities show significant diversification premiums under the strict regulation. However, they insist that these diversification premiums disappeared when partial deregulation of the industry is implemented.

Diversification strategies of water and sewerage companies (WaSCs) in England and Wales and newly privatised UK utilities, water and electricity companies, is also examined by previous literature. Since privatisation in November 1989, the water

sector in England and Wales consists of 10 regional monopolies providing both water and sewerage service (WaSCs) and 9 water-only companies (WoCs) with regional monopolies operating in the areas of the WaSCs (OFWAT, 2015). Especially, WaSCs exist as group structure and each licensed water company is owned by a parent company (water holding company). Water subsidiaries can also deploy non-regulated business as same as other subsidiaries in the group company (OFWAT, 2006). While The Water Act 1973 constrained other activities except water supplies, the authorities were partly permitted to enter the overseas activities such as advice, assistance and training, only under the agreement of central government after The Water Act 1983. Finally, The Water Act 1989 offered the opportunity for diversification into non-regulated businesses, as well as introduction of commercial decision making to the regulated core business (McGuinness & Thomas, 1997; OFWAT, 2006). At the first stage of privatisation, WaSCs had abundant cash, but its core business was matured, regulated, and uncertain about future profitability, thus, these situations motivated them to enter unregulated markets, which allow greater freedom to make strategies and expect future growth (McGuinness & Thomas, 1997; Thompson, 1999). McGuinness and Thomas (1997) argued that managements of WaSCs desired diversification strategies to secure alternative sources of income and profit because it is difficult to expect high growth for regulated water business and water business required a large scale investment to satisfy enhance environmental regulations and to improve the level of service. Therefore, they transferred their funds to enter the new opportunity to diversify as described in the situation of free cash flow (McGuinness & Thomas, 1997; Thompson, 1999). Most companies tended to diversify into businesses involving water and sewerage activities. In addition, WaSCs extended their business area into property development, hotels and fisheries; regional television broadcasting; landscaping; and security services (McGuinness & Thomas, 1997). In the report of OFWAT (2006), diversifying activities of WaSCs are defined as following ways: 1) by shifting some regulated businesses (e.g. transport,

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<sup>1</sup> According to McGuinness and Thomas (1997), the water authorities invested in telemetry (computerised remote monitoring and control of operations), digital mapping, computerised systems, and closed circuit television surveying of mains and sewers before privatisation.

IT, scientific or customer services) to separate companies which continue to trade with the regulated business; 2) by assigning the non-regulated businesses to subsidiaries and offering these services to third parties and to the regulated business; 3) by developing services or companies which supply goods or services to the regulated business as a form of subsidiary; 4) by entering into joint ventures with other companies. Diversification strategies of WaSCs are regulated by directors (OFWAT) to prevent the customers from undeserved burden caused by potential losses or higher charges which may be caused by diversification, through monitoring any transactions with group firms (OFWAT, 2006).

McGuinness and Thomas (1997) illustrate the conformity to the privatisation of the WaSCs resource view. After privatisation, WaSCs deploy diversification strategies to overcome slow growth of water and sewerage industry, and to secure funds for investment in infrastructure in order to improve service level. In this circumstance, WaSCs strive to exploit core competencies like customers, network, and work routines built by operating water and sewerage business, for diversification. They expand the extent of business by overcoming disadvantages through merger and acquisition, and strategic alliance, and building new core competencies. Thomson (1999) investigates the post-privatisation UK energy and water utilities aspects of the free-cash flow hypothesis. Because of weak governance and strong cash-flow after privatisation, their diversification strategies are encouraged and non-core revenues are also increased.

On the other hand, telecommunication industry in the U.S. focuses on international diversification. Before 1996, when The Telecommunications Act of 1996 was enforced, the telecommunications markets in the U.S. were separated into two sectors, which were regional bell operating and long distance services including international calling. With developments in technology, the third sector, offering cellular or paging services, appeared later, thus, there were three types of market in telecommunications industry. Originally, there was boundary within industry, which didn't allow each firm to transfer from its own sector to the other sectors (Ware, 1998). Therefore, they were only allowed to compete in other sectors within its jurisdiction, in noncore business in the

other firms' operating regions, or in overseas markets because it is legally restricted to operate core business in other regions of U.S. (Kashlak & Joshi, 1994; Ware, 1998). As a result, telecommunications firms diversified into closely related markets (e.g. regional toll of long distance companies and carrier access for large customers) and new region geographically and internationally. However, the implementation of The Telecommunications Act 1996 increased competition in telecommunications market by allowing long distance companies to provide local services, and between cable TV and telephone companies. In other words, the law gave the firms opportunities to deploy their businesses over nationwide and various industries by eliminating regional and industry boundaries (Joshi, et al., 1998; Ware, 1998). As well as regulatory reason, network economies (e.g. economies of scale and scope obtained by intensive use of the existing network) also motivated diversification. Particularly, customers' needs to one-stop-shopping made the firms to diversify into competitors' markets in order to stimulate demand (Ware, 1998). As a result, the telecommunications companies have formed full service firms providing several telecommunication services, such as regional and long distance, mobile telecom, internet and cable TV, and entered the international market. Kashlak and Joshi (1994) use the Regional Bell Operating Companies (RBOCs) in U.S. as the sample and assume that the diversification strategies of RBOC are determined by core business growth and degree of government regulation. They point out that regulated telecommunication firms might invest in international diversification if the growth of core business is stagnant.

## **Summary**

The aim of diversification strategies is to create value, to make firms grow, and to improve profitability. The firms also seek expansion of business, stabilisation of profit, and compensation for the deterioration of technologies and low growth of core business by diversifying. In perspectives for the motivation of the firm's diversification, three points of view are suggested: 1) market power view, 2) resource view, 3) agency views.

Types of diversification strategies are also a main issue of research on diversification. Rumelt (1974) classifies types of diversification in nine categories including four main categories and five subcategories which are derived from main categories, based on the relatedness existing among the firm's various businesses. Intangible assets and financial resources which the firm possesses, especially obtained from research activities, are likely to be associated with the related diversification.

Relationship between the extent of diversification strategies and the firm's performance is examined by lots of literature. Most of them support that related diversification is the most effective way to increase profitability and this is represented by inverted-U model. According to inverted-U model, the firm's performance tends to decrease after critical point, thus, unrelated diversification might not yield high profitability.

While research on diversification strategies generally uses manufacturing and unregulated firms as a sample, diversification strategies of non-manufacturing firms and regulated firms are also investigated under the diverse view. The cases of American electric utilities, public utilities in the U.K., and telecommunication industry are reviewed. Public utilities expand their business into non-regulated industry and beyond the geographic region to attenuate monitoring costs and use core competencies built by core business. From the next chapter, diversification strategies of Japanese PRCs will be discussed based on various discussions of this chapter and environment of urban transportation is also reviewed.

### 3. Diversification Strategies of Japanese PRCs

While many operators of urban public transportation are suffering from a decrease of ridership and operating deficits due to inefficient operation in most industrialised countries, railway transportation in large urban areas of Japan is differentiated by its operation making a profit and efficiency. Railway transportation in Japan can be also characterised by operators run independently of the government and its business strategies. In this chapter, this study reviews the current situations of urban transport systems and private railway operators in Japan.

#### Overview of Urban Transportation in Japan

In Japan, high public transit usage in huge metropolitan areas, which are Tokyo metropolitan area and Keihanshin area, is the main feature of urban transportation. Table 3.1 presents mode share in Tokyo metropolitan area (TMA), Keihanshin metropolitan area (KMA), and Chukyo metropolitan area (CMA). TMA and KMA show high proportion of public transit, including railway, bus and taxi, and it is more than half, while car is the most overwhelming mode in CMA as accounting for 72.9%.

*Table 3.1 Mode share in three metropolitan areas of Japan (2008)*

	Railway	Bus	Taxi	Car
Total (three areas)	51.0	6.6	2.7	39.7
Tokyo metropolitan area	58.2	6.8	2.7	32.3
Keihanshin metropolitan area	48.4	7.8	3.2	40.6
Chukyo metropolitan area	21.7	3.6	1.8	72.9

Note 1) Trams are included in the bus.

2) The original data was adapted for the purpose of study

Source: Transportation Policy Studies (Unyu Seisaku Kenkyu Kikou), 2011

(1) Pure private railway companies and operation independently of governments

Many of the companies established during the large-scale construction of railways in the late 19<sup>th</sup> century and the early 20<sup>th</sup> century in Japan, still exist today in the form of PRCs. On the contrary, the main operators of urban railways in the United States and Europe have changed from the private to the public sector because of financial

difficulties or through the discontinuation of deficit-ridden railway lines (Shoji, 2001).

The main operators of urban railway in Japan are usually classified into, JRs (Japan Railway), private railways and public and quasi-public firms. Among these operators, Private railway companies (PRCs hereafter) play a large role as organisations run independently of the government. According to the Ministry of Land, Infrastructure, Transport and Tourism of Japan, there are 177 passenger railway operators in Japan (excluding cable car, ropeway and non-passenger rail operators like freight operator) and 142 of these firms are categorised as PRCs (major, semi-major and minor) in 2012. Of these, 16 firms were 'major' companies, namely those that provided services in Japan's three metropolitan areas, which are characterised as having large demand for railway services (except Nishi Nippon Railroad). Operators of subway lines like Tokyo Metro and Osaka Municipal Transportation Bureau, and six JR companies (JR Hokkaido, JR East, JR Tokai, JR West, JR Shikoku, JR Kyushu) are not included in private railway.

Most of Japan's 16 PRCs and three JR companies (JR East, JR Tokai, and JR West) in Honshu are listed on Tokyo stock market, and these have formed group firms that have several subsidiary companies. They receive few operating subsidies from the government, although some financial support programmes are available such as loans without interest or with interest relief and tax relief on funds for infrastructure investment (Shoji, 2001). Therefore, they design and provide services independently without government intervention. Although PRCs generally face regulations related to market entry, fares (full-cost pricing), and safety standards in the railway business, owing to public concerns, they are not operated or managed by the public sector.

## (2) Urban railway operation in surplus

While numerous PRCs in Europe and North America established during the 'railway boom' went bankrupt because of financial difficulties, PRCs in Japan survived by operating profit-making passenger railways in urban areas (see Figure 3.1). Especially, major PRCs in urban area do not receive any subsidies for their operation and this distinguishes Japanese PRCs from urban railway operators of other

developed countries. In addition, they invest to construct and maintain infrastructure by their own funds without any subsidies from the public sector in substance (Shoji, 2001). Japanese PRCs in urban areas can be profitable because 1) they operate in densely populated urban centres 2) they operate in a competitive environment under competitive principles, and 3) they have a stable base of pre-paid commuter passengers (Killeen, 1999). Because they usually started operations in relatively undeveloped areas, it is especially remarkable that the most of them are making profit considering poor initial condition (Saito, 1993; Killeen, 1999; Shoji, 2001).

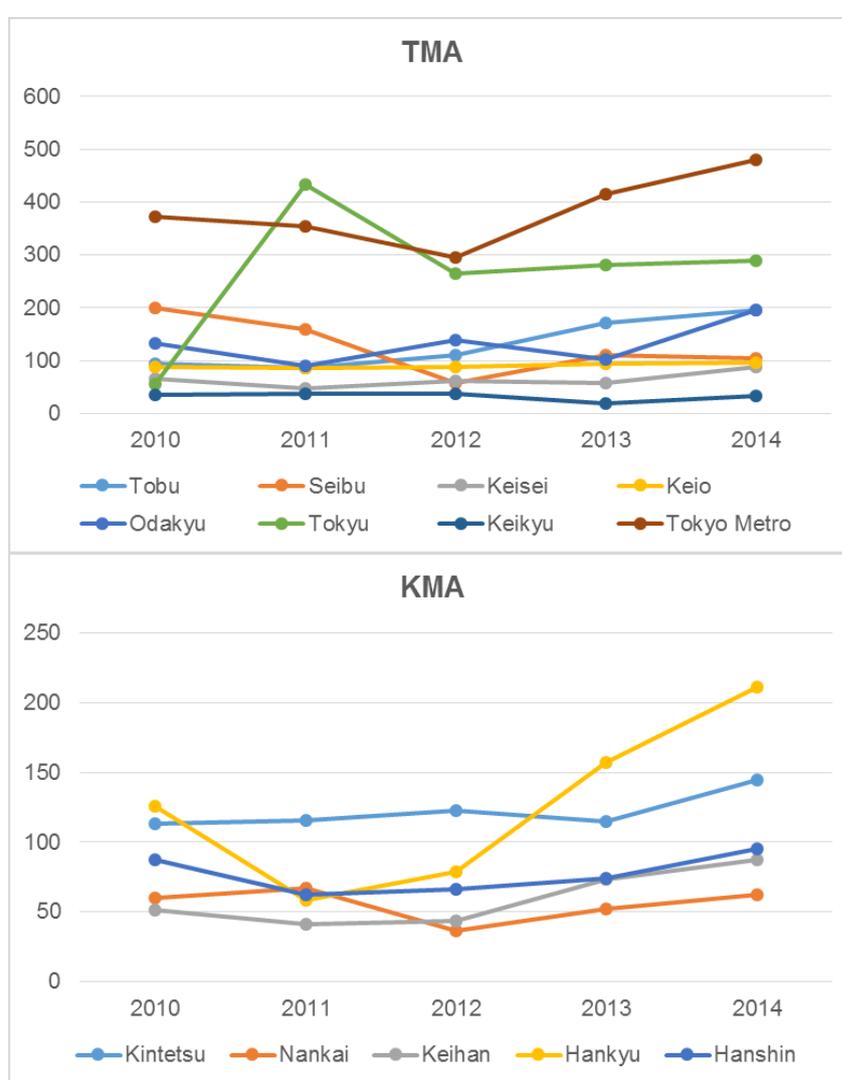


Figure 3.1 Net profit of major PRCs in TMA and KMA for 5 years  
(Unit: one hundred million Yen)

Source: The data book of the major private railways (2011-2014), The Association of Japanese Private Railway

### (3) Diversification and integration strategies of PRCs

PRCs diversify into several different fields, as well as railways and employ integration strategies. Diversification strategy has been employed in a form of not only business unit inside a corporation, but also subsidiaries in group system. They have faced with price regulations (e.g. full-cost pricing) and fare regulations, thereby limited profitability. Therefore, considering the limited profitability of the railway business because of these regulations, it is regarded as natural and rational for PRCs, as private enterprises, to participate in new businesses that are free from regulation (Shoji, 2001). They also try to capture externalities due to the initial railway infrastructure investment (Killeen, 1999). Diversification of public utility companies can be observed in case of the electric utility industry in the U.S. and the water and sewerage companies in England and Wales, as well as private railway companies in Japan (Russo, 1992; McGuinness & Thomas, 1997). Retaining enough population density is often referred as the key point for the profitable operation of railway business; however, Killeen (1999) insists that it is not the only factor that guarantees success. Hard condition starting business in the undeveloped areas, having scarce ridership, at the initial stage made PRCs to struggle to create demand for an increase of ridership. In other words, they achieve profitable operation of railways by property development of surrounding areas, station development and other business ventures, thereby making new demand, rather than relying on the living population already existed. However, it should not be forgotten that income from diversified non-rail businesses cannot be used to make up for the loss of railway business because railway and other diversified businesses are strictly separated by Railway Accounting Ordinance (Tetsudo kaikei kisoku) which prohibits cross-subsidisation in terms of cost allocation between railway and diversified non-rail businesses (Shoji, 2001).

### **Diversification Strategies of PRCs in Japan**

#### (1) Overview of diversification strategies of PRCs in Japan

Major PRCs in Japan have mostly diversified into real estate and distribution,

including the retail business. Leisure and service business are also important, such as the hotel business locally and nationwide. The maintenance of buildings and the manufacturing or maintenance of railway carriages are other main businesses, although the proportion of revenue of these is low compared with that of other businesses, because of vertical integration, which reduces operating costs. Although classification of segment is different by each PRC, they generally operate the following businesses (Shoji, 2001): 1) transportation (passenger transportation including railway, bus and taxi, and freight transportation), 2) real estate and construction (constructing, selling and leasing houses and buildings, and building management), 3) distribution (department stores, convenience stores, and supermarkets inside or around their terminal buildings and stations), 4) leisure (travel, amusement park, hotel, and sport facilities and teams), 5) manufacturing (railway carriages and plants), 6) IT and service (CATV, communication, advertisement and finance and insurance), 7) culture and entertainment (museum, opera company, and nursing home).

In recent years, as main diversified business, PRCs have actively operated real estate business focusing on the selling and leasing of houses and buildings near their routes, as well as development residential and commercial area and construction of building and house. Distribution business is also a main diversified business in PRCs, especially focusing on the retailing. It is not hard to find convenience stores, which are brand of PRCs, inside or near a terminal building and station, such as 'Asnas (Hankyu-Hanshin Holdings)' and large department store, such as 'Hankyu department store', 'Tokyu department store', or 'Kintetsu department store' named after the name of PRCs. In addition, the proportion of diversified businesses including real estate and distribution to entire segments is quite high, according to the financial statement and annual report of each company. In other words, PRCs diversify their businesses by utilising the physical resources which are emphasised in the railway business. PRCs also try to attract passengers using their railway service to commercial facilities operated by them and utilising customer asset to increase profitability.

On the other hand, PRCs also deploy leisure and service business even in country wide and abroad, as well as near operating area. Especially, one of the subsidiary of Hankyu-Hanshin Holdings, "Hankyu Travel" provides services for domestic and overseas travels, and Tokyu Corporation develops resort facilities and sports facilities outside operating area. Building maintenance and manufacturing or maintenance of rolling stocks is also one of the diversified businesses, but, the proportion is not high compared with other businesses. These are usually considered as the result of vertical integration in order to reduce operating cost (Shoji, 2001).

## (2) The analysis of diversification strategies of Japanese PRCs

Many previous studies investigating diversification strategies of Japanese PRCs focus on the classification of type of diversification strategies, discussed in strategic management. Although the relationship between strategic type and profitability is also one of the main topics of diversification strategies of Japanese PRCs, there are few studies examine this relationship quantitatively, except for the research of Yoshida (1986), Killeen (1999), Shoji (2001), and Kamata and Yamauchi (2010). Of these, Yoshida's (1986) research is the first quantitatified one which adopts Rumelt's (1974) method, which is modified considering the industry characteristics of the transportation industry in Japan. He analyses the relationship between type of diversification and performance, focusing on profitability. Table 3.2 presents the comparison of classification of diversification strategies by Rumelt and Yoshida.

*Table 3.2 Classification of diversification strategies of Rumelt and Yoshida*

Rumelt (1974)		Yoshida (1986)	
Category	Criteria	Category	Criteria
Single business	$SR \geq 0.95$	Single business	$SR > 0.90$
Dominant vertical	$SR < 0.95$ or $VR \geq 0.7$	Dominant vertical	$VR > RR > 0.70$
Dominant Constrained	$SR \geq 0.7, VR < 0.7$	Dominant business	$SR > 0.70$
Dominant Linked			
Dominant unrelated	$SR \geq 0.7, VR < 0.7,$ $RR < \frac{1}{2}(SR+1)$		
Related constrained	$SR < 0.7, VR < 0.7,$ $RR \geq 0.7$	Related business	$RR > 0.70$
Related linked			
Unrelated business	$SR < 0.7, VR < 0.7,$ $RR < 0.7$	Unrelated business	

- Note 1) SR (Specialization Ratio): The proportion of a firm's revenues that is attributable to its largest discrete product-market activity
- 2) VR (Vertical Ratio): The proportion of a firm's revenues attributable to all of the by-products intermediated products, and final products of a vertically integrated sequence of manufacturing operations
- 3) RR (Related Ratio): The proportion of its revenues that is attributable to the largest group of businesses that are related in some way to one another

Source: Rumelt (1974), Yoshida (1986) (The original source chart and table were adapted for purposes of the study.)

After Yoshida (1986), Killeen (1999) and Shoji (2001) also classify types of diversification strategies of the fifteen major PRCs using Yoshida's (1986) method. They find that the strategic positioning of these is steadily maintained, and related diversified firms can be observed in the KMA more than in the TMA. In addition, the profitability of related diversified firms is higher than that of any other firms in the sample. This indicates that an increase in the extent of diversification may cause a decrease of performance above a certain degree of diversification. This is consistent with Rumelt's (1974) results. However, Kamata and Yamauchi (2010) claim that the profitability of dominant firms is higher than that of any other types in the analysis of major PRCs and three of JR companies including data after 1996. They find that the profitability of dominant firms is higher than that of other categories (single and unrelated type).

Different conclusions of these studies may result from the difference in data which are used in the analysis. While Killeen (1999) and Shoji (2001) focus on the in-house level strategies and use the data of securities report of each subsidiary, Kamata and

Yamauchi (2010) set the range of analysis in the group-level and use the data from consolidated financial statement. Although the in-house level strategies generally tend to focus on the increase railway ridership, the group-level strategies are likely to emphasise to improve profitability and growth of the entire firm (Saito, 1993; Mizutani, 2006). Moreover, most of Japanese firms, as well as PRCs, experienced the change of accounting rule after 2000. The consolidated financial statement, which Kamata and Yamauchi (2010) used, is an accounting rule considering the holding company's subsidiaries into its aggregated accounting figure and it focuses on the performance of the group as a single entity. Therefore, it is hard to capture the activities of subsidiaries which are not needed to be obliged to announce financial statements because all intragroup transactions and balances are excluded to avoid double counting.

Difference in the definition of vertical and relatedness business is also considered as the reason of different conclusion. Kamata and Yamauchi (2010) adopt segments written in the consolidated financial statement as business categories and each PRC decides segments based on its managerial decision. However, Killeen (1999) and Shoji (2001) adopt modified standards, which apply the rules of Kintetsu Electric Railway, to unify the business categories of each PRCs. They define business categories by 'vertical', 'related' and 'unrelated' ratio of each business considering the actual condition of PRCs.

Shoji (2001) also analyses diversification strategies of PRCs in the group-level, but he redefines business segments as similar to the in-house level analysis. In this analysis, he investigates diversification strategies by the proportion of revenue and profit of each segment to the entire firm, rather than categorising the type of diversification strategies. He also refers that PRCs may be classified into unrelated type in the group-level analysis because PRCs deploy business not only near the route and related to transportation business, but also outside the route and not highly related to transportation business. In this group-level analysis, he insists that diversification beyond the appropriate level influences on the firm's profitability negatively by comparing the ratio of profit of each segment to entire firm and

transportation and real estate segment are important businesses for PRCs because the profit of PRCs consists of those from two businesses.

Analysis for minor PRCs is also conducted by Shoji and Killeen (2001). Minor PRCs include all the firms except major PRCs and JR companies, and they provide railway services in local city areas, as well as operating a sightseeing train. Comparing to major PRCs, while the size of the railway business is not large and varies depending on the operator, most of minor PRCs diversify into various businesses as major PRCs do. Shoji and Killeen (2001) compare the extent of diversification strategies and composition of the operating income of each segment. They argue that the diversification index of minor PRCs which represents the extent of diversification strategies is not largely different from that of major PRCs, although they are likely to diversify more into the automobile business including bus and taxi. The tendency of high proportion of automobile business is due to poor demand condition of local area, thus, bus transportation functions complementary with railway service. They also investigate the type of diversification strategies of minor PRCs using Rumelt's method and suggest that more than half of the firm classified into unrelated firm, although diversification index is not largely greater than that of major PRCs. Shoji and Killeen (2001) interpret that this result is attributed to weak business foundation of railway operation and also argue that same tendency with major PRCs is observed in the relationship between the extent of diversification and profitability.

### (3) Effect of diversification strategies on railway business

Killeen (1999) refers cross-traffic effect on his doctoral thesis for the almost first time. Cross-traffic effect can be defined as increased ridership by developing housing and land in the area along railway routes or utilising railway passenger (Shoji, 2001). The concept of cross-traffic effect was started from the question why the firms continue to operate deficit diversified businesses and do not divest non-profitable segments. If cross-traffic effect, facilitating railway demand by diversified businesses, exists, the divestiture of non-profitable businesses might negatively influence railway business. Killeen (1999) and Sugiyama (2000) estimate quantitative models based

on the demand function using ordinary least squares (OLS hereafter). Table 3.3 presents the models of two research.

*Table 3.3 Models of cross-traffic effects*

Variables	Data	
	Killeen (1999)	Sugiyama (2000)
D (Dependant Variables)	Total passenger	Total passenger
	Non pass holders	Non pass holders
EC (Economic Conditions)	Real economic growth rate	Real economic growth rate
	Total population (along the railway line)	Total population (along the railway line)
SU (Price of Substitute Services)	Gasoline retail price index	Gasoline retail price index
	Total number of cars	
FA (Rail Fares)	Fare indicator	Average fare (commuter/ excepting commuter)
QS (Quality and quantity of Service)	Rail traffic density	Operation kilometer
	Number of rail employees	
DO (Effects of Diversified Operations)	Rail investment	Goods, land and objects (inventory assets)
	Investment on diversified operations	Income from the lease business of land and building
		Income from other diversified businesses

Source: Killeen (1999), Sugiyama (2000)

Regarding comparison of two models, while Sugiyama (2000) tries to capture the effect of diversified businesses by classifying income from diversified businesses into real estate oriented and others, Killeen (1999) considers railway operation and others only. Killeen (1999) also assumes that investment in diversified businesses might influence on the passengers' usage status excepting commuters, however, this is not statistically significant. On the contrary, Sugiyama (2000) suggests statistically significant evidence that investment in diversified businesses influences on non-commuter passengers. Difference of conclusions of two model results from difference of used sample in analysis. While Killeen (1999) uses the data of the business units of Hankyu Railway, Sugiyama (2000) estimates model using data of Keihan Electric Railway (Keihan) and Kintetsu Electric Railway (Kintetsu). In his analysis, although Keihan acquires passengers by diversifying into the real estate and other businesses, it is not observed in the case of Kintetsu. However, it is hard to conclude that Kintetsu

does not receive any benefits from diversification strategies for increase ridership. He refers that the strategic level (in-house or group) of diversification should be scrutinised to clarify the effect of diversification strategies on railway ridership.

## **Summary**

PRCs are the most important transportation in urban areas of Japan for now, attracting a large number of riders. They provide passenger railway services making a profit, although they are regulated in terms of fare, pricing, and safety, and there are only minimal financial support schemes for building and maintaining infrastructure. Innovative diversification strategies contribute to the successful operation of PRCs by making various income sources which enable them to overcome limited profitability of railway business.

Diversification strategies of PRCs are the most distinctive feature comparing with other operators in developed countries. PRCs have mainly diversified into the businesses significantly associated with passengers' daily life, like retail and real estate focused on selling and leasing, while transportation business, including railway business is still an important business generating stable profit to the firm. Previous studies investigate the relationship between diversification strategies and performance of PRCs in terms of profitability, by classifying the type of diversification strategies. For the relationship between diversification strategies and profitability, Killeen (1999) and Shoji (2001) insist that related diversified firms are the most profitable while Kamata and Yamauchi (2010) suggest different conclusion. Disagreement of results resulted from different data structure and different standard to decide vertical and related businesses. With the regards of types of diversification strategies, quantitative models are estimated to measure cross-traffic effects, while only small number of research tries. From the next chapter, the empirical analysis on Japanese PRCs using quantitative model will be conducted based on the discussion of diversification strategies reviewed so far.

## Appendix 3.A List of Diversified Businesses of Japanese PRCs<sup>2</sup>

Operator	Core business	Diversified segments				
Tobu	Transportation - Railway - Bus and taxi - Freight	Leisure - Amusement park, tourism - Sports business - Hotels - Restaurant	Real estate - Leasing and selling - Development of Tokyo Sky Tree	Distribution - Retail (department store)	Others - Construction of housing	
Seibu	Urban transportation and regional business - Railway - Bus - Leisure business in operating region of railways	Hotel & leisure - Hotel - Resort - Golf courses	Real estate - Leasing - Stores in stations	Construction - Construction of railway facilities and housing	Hawaii - Hotel and resort	Others - Leisure business of subsidiaries operating local railways - Baseball team
Keisei	Transportation - Railway - Bus and taxi	Distribution - Department store - Wholesale of garden plants - Shopping mall	Real estate - Leasing and selling - Management of property	Leisure & Service - Restaurant and theatre - Hotel - Advertising - Tourism	Construction - Construction of housing	Others - Maintenance of rolling stocks - Car manufacturing - Insurance agency
Keio	Transportation - Railway - Bus and taxi	Distribution - Department store - Retail store - Book store - Stores in stations	Real estate - Leasing and selling	Leisure & service - Hotel - Tourism - Advertising	Others - Building management - Maintenance of rolling stocks - Construction	

<sup>2</sup> Diversified segments are lined up by following the order of financial statement of each company in 2012.

Operator	Core business	Diversified segments				
Odakyu	Transportation - Railway - Bus and taxi - Cable car	Distribution - Department store - Retail store	Real estate - Leasing and selling	Others - Hotel - Restaurant - Tourism - Building management		
Tokyu	Transportation - Railway - Bus	Real estate - Leasing and selling - Management of property	Retail - Department store - Franchise store - Shopping mall	Leisure & services - Advertising - Cable TV - Childcare	Hotel	Others - Manufacturing of rolling stocks
Keikyu	Transportation - Railway - Bus and taxi	Real estate - Leasing and selling	Leisure & Services - Hotel and restaurant - Leisure facilities and golf courses - Advertising	Distribution - Department store - Retail store - Stores in stations	Others - Construction - Building management	
Sagami	Transportation - Railway - Bus	Construction - Construction of housing	Distribution - Supermarket - Sales of gravel and pebble for construction	Real estate - Leasing and selling	Others - Building management - Hotel - Advertising	
Nagoya	Transportation - Railway - Bus and taxi	Logistics - Trucks - Maritime transportation	Real estate - Leasing and selling	Leisure & service - Hotel - Operation of tourist facilities - Tourism	Distribution - Department store	Others - Maintenance of railway facilities - Aviation - Building management
Kintetsu	Transportation - Railway - Bus and taxi - Maritime transportation - Maintenance of railway facilities	Real estate - Leasing and selling - Management of property	Distribution - Department store - Retail store - Restaurant	Hotel & leisure - Hotel - Tourism - Movie theatre - Leisure facilities	Others - Cable TV - IT - Insurance agency	

Operator	Core business	Diversified segments				
Nankai	Transportation - Railway - Bus - Maritime transportation - Freight - Maintenance of rolling stocks	Real estate - Leasing and selling	Distribution - Shopping mall - Retail store	Leisure & services - Amusement park - Building maintenance - Printing - Advertising	Construction	Others
Keihan	Transportation - Railway - Bus and taxi	Real estate - Leasing and selling - Construction	Distribution - Department store - Shopping mall - Retail store	Leisure & services	Others	
Hankyu-Hanshin	Urban Transportation - Railway - Bus and taxi	Real estate - Leasing and selling - Development of commercial facilities	Entertainment & communication - Baseball team - Musical theatre troupe - Cable TV - Leisure facilities	Tourism & international transportation	Hotel	Distribution - Retail store - Restaurant  Others - Construction - Domestic logistics
Nishitetsu	Transportation - Railway - Bus and taxi	Real estate - Leasing and selling	Distribution - Retail store	Logistics - International logistics - Domestic logistics	Leisure & service - Hotel - Tourism - Entertainment - Restaurant - Advertising	Others - Maintenance of rolling stocks - Construction - Recycling metals

## **4. Diversification Strategies and Technical Efficiency as Performance**

Although performance encompasses multiple dimension of a firm's strategy, most of research on the relationship between diversification strategies and performance focuses on the accounting-based measures related to financial returns. In this chapter, the relationship between diversification strategies and performance is discussed based on the different perspective with previous research, which considers a firm's performance as the level of efficiency with consideration for economies of scale and scope.

### **A Firm's Efficiency and Performance**

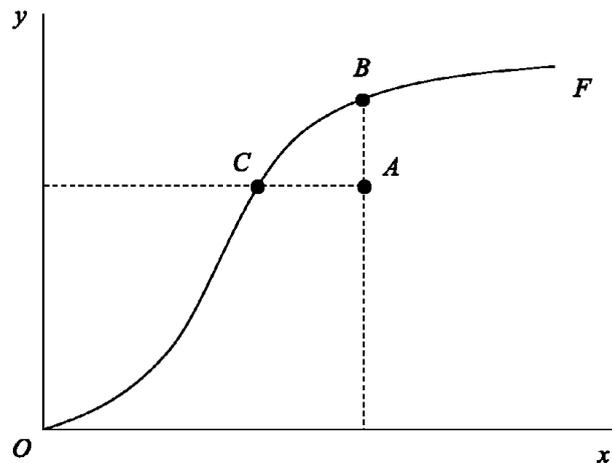
Since Porter (1985) refers competitive advantages relative to the majority of rivals, assessing its effect on a firm's performance is a challenge for many researchers. Previous studies on Japanese PRCs assume that the type and the extent of diversification strategies is one of the factors bringing on competitive advantages to the firms and that struggle to clarify the effect of diversification strategies on the firm's performance.

Chen, Delmas, and Lieberman (2015) point out that most of previous research on strategic management cannot capture a diverse array of objectives and actions regarding the creation of competitive advantage. They also argue that the firm's performance has been measured by imperfect measurements which only identify average effects in a sample and assess a single performance dimension, and that purely financial measures can ignore a firm's efficiency transforming resources, which may be a major source of competitive advantage. Further, in resource view, competitive advantages are linked to resources and capabilities which the firm owns and these are connected with superior performance (Porter, 1985). Especially, capabilities imply the ability of the firm combining efficiently resources it owns to accomplish productivity and certain objective (Amit & Schoemaker, 1993; Dutta, et

al., 2005; Lieberman & Dhawan, 2005). Therefore, capabilities can be considered as the efficiency with which a firm uses its own inputs and converts them into desirable outputs for it, and are related to an 'intermediate transformation ability' between resources and products (or objectives) (Dutta, et al., 2005).

Diversified firms produce multiple outputs using multiple inputs, which are labour, capital and other potential inputs. In the same industry, some firms achieve more productive outputs than those of other firms and it is represented by differences of quality of quantity of outputs the firm produce. These differences originate from the firm's capabilities, transforming inputs to outputs, and can be also considered as efficiency among the firms, as discussed above. The firm's activity, producing outputs using inputs, is captured by production function, and stochastic frontier analysis provides a framework assessing efficiency and offers advantages by estimating both production function and the determinants of firm efficiency in a single stage (Lieberman & Dhawan, 2005).

On the other hand, productivity and efficiency have been used interchangeably, however, these are not exactly the same concept in fact (Coelli, et al., 2005). Although productivity is simply defined as the ratio of the outputs of the firm to the inputs used which is described as the tangent of the line from  $O$  the point of the production set, efficiency is related to whether a firm produces its outputs on maximum level given inputs, described as differentiation at the point of the production set. Especially, technical efficiency refers to the ability to minimise input use in the production of a given output set, and technically efficient firm operates on a line of production frontier, while a firm operating beneath the frontier line is technically inefficient (Kumbhakar & Lovell, 2003; Coelli, et al., 2005). Figure 4.1 describes production frontiers and technical efficiency. Although a firm operating at point  $B$  and  $C$  is efficient, a firm operating at point  $A$  is inefficient, because it could technically increase output to the level of the point  $B$  without requiring more input.



*Figure 4.1 Production frontiers and technical efficiency*

Source: Coelli, et al. (2005), pp. 4

Technical efficiency is broadly used in many research fields, such as retailing (Park & King, 2007) and agriculture (Paul & Nehring, 2005; Newman & Matthews, 2006). In the strategic management, Lieberman and Dhawan (2005) and Chen, et al. (2015) link the effects of resources and capabilities to the firm performance measured by technical efficiency using data on Japanese and U.S. automobile manufacturing firms. Dutta, et al. (2005) also investigate the effects of R&D activities of the firms on the firm's production of innovative technologies using data of the firms which produce semiconductors and computers in U.S. by estimating R&D frontier/transformation function and comparing efficiency of each firm which represents R&D capability.

### **Describing Multiple Inputs – Multiple Outputs Production Technology**

Shephard suggested distance functions to define production technology using multiple inputs to produce multiple outputs. There are two types of distance functions, which are input and output distance functions. Input distance functions characterise input sets, and output distance functions characterise output sets (Kumbhakar & Lovell, 2003). Distance functions describe the structure of production technologies and the estimates measured by distance functions relate to the measures of technical efficiency. This study focuses on the output distance functions.

<sup>3</sup>The graph of the firm's production technology using input vector  $\mathbf{x}$  can be defined as  $P(\mathbf{x})$ , which represents the set of all output vectors,  $\mathbf{y} \in R_+^M$ , which can be produced using the input vector,  $\mathbf{x} \in R_+^N$ . Therefore,  $P(\mathbf{x})$  can be described as follows:

$$P(\mathbf{x}) = \{(\mathbf{y}, \mathbf{x}) : \mathbf{x} \text{ can produce } \mathbf{y}\} \quad (4.1)$$

Output set  $P(\mathbf{x})$  satisfies the following properties (Kumbhakar & Lovell, 2003):

- 1)  $P(0) = \{0\}$
- 2)  $P(\mathbf{x})$  is a closed set.
- 3)  $P(\mathbf{x})$  is bounded for  $\mathbf{x} \in R_+^N$ .
- 4)  $P(\lambda\mathbf{x}) \supseteq P(\mathbf{x})$  for  $\lambda \geq 1$
- 5)  $\mathbf{y} \in P(\mathbf{x}) \rightarrow \lambda\mathbf{y} \in P(\mathbf{x})$  for  $\lambda \in \{0, 1\}$
- 6)  $\mathbf{x}_1 \geq \mathbf{x}_2 \rightarrow P(\mathbf{x}_1) \supseteq P(\mathbf{x}_2)$  and  $\mathbf{y}_1 \leq \mathbf{y}_2 \in P(\mathbf{x}) \rightarrow \mathbf{y}_1 \in P(\mathbf{x})$
- 7)  $P(\mathbf{x})$  is a convex set for  $\mathbf{x} \in R_+^N$ .

An output distance function is defined on the output set,  $P(\mathbf{x})$ , as (4.2):

$$D_o(\mathbf{x}, \mathbf{y}) = \min\{\mu: \mathbf{y}/\mu \in P(\mathbf{x})\} \quad (4.2)$$

The function measures the distance from a producer to the boundary of production possibilities. The distance gives information about whether an output vector can be closer to optimal production possibilities and remains producible with a given input vector. Figure 4.2 illustrates an output distance function in case of producing two outputs. The firm can still produce at the output vector  $\mathbf{y}$  using input vector  $\mathbf{x}$ , but expand production radically to output vector  $(\mathbf{y}/\mu^*)$ , and so  $D_o(\mathbf{x}, \mathbf{y}) = \mu^* < 1$ .

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<sup>3</sup> For details, see Coelli & Perelman (2000).

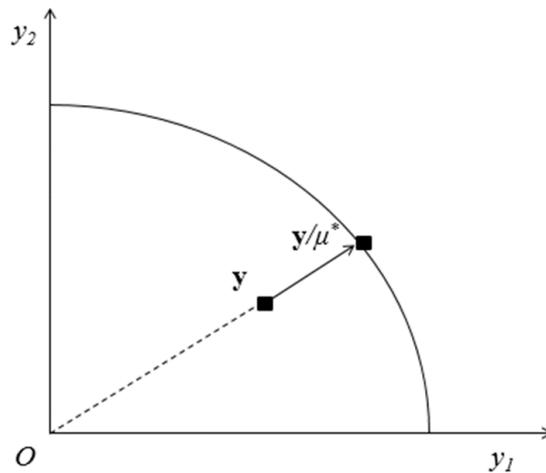


Figure 4.2 An output distance function ( $M=2$ )

Source: Kumbhakar & Lovell (2003), pp. 31 (Figure 2.11)

The output distance functions satisfies the following properties because it is defined by the output sets,  $P(\mathbf{x})$  (Lovell, et al., 1994):

- 1)  $D_o(\mathbf{x}, \mathbf{y})$  is nondecreasing, positively linearly homogeneous.
- 2)  $D_o(\mathbf{x}, \mathbf{y})$  is a convex function in  $\mathbf{y}$ , and decreasing in  $\mathbf{x}$ .
- 3)  $D_o(\mathbf{x}, \mathbf{y}) \leq 1$  if  $\mathbf{y} \in P(\mathbf{x})$
- 4)  $D_o(\mathbf{x}, \mathbf{y}) = 1$  if  $\mathbf{y} \in \text{Isoq } P(\mathbf{x}) = \{\mathbf{y}: \mathbf{y} \in P(\mathbf{x}), \omega \mathbf{y} \notin P(\mathbf{x}), \omega > 1\}$

Therefore, the output isoquant described above is a possible standard against which to measure the technical efficiency of output production. If the firm's production set lies on the frontier (isoquant), the firm efficiently produces outputs at the optimal point.

### Production Function

The functional relationship between inputs and outputs in generally expressed by the production function (Coelli & Perelman, 2000), and the output distance function can be described by production function. In case of the firm producing only one output using multiple inputs, production function can be written in the form:

$$y = f(x_1, \dots, x_n) \quad (4.3)$$

where,  $y$  is the dependent variable,  $x_n$  ( $n = 1, \dots, N$ ) are explanatory variables,

and  $f(\cdot)$  is a mathematical function. Regarding inputs, capital and labour are generally used and, land, law materials, and machinery are also used depending on the production process. To estimate the relationship between the dependent variable and independent variable, functional form should be specified based on the economic theory (Coelli, et al., 2005). Table 4.1 lists some common functional forms generally used in research estimating production function, and  $\gamma, \beta_n$  and  $\beta_{mn}$  are unknown parameters to be estimated. Especially,  $\beta_{mn}$ s satisfy a symmetry condition, which is  $\beta_{mn} = \beta_{nm}$  for all  $n$  and  $m$ . Therefore, the Cobb-Douglas is a special form of the translog when all  $\beta_{mn}$ s equal to 0.

*Table 4.1 Common functional forms of production function*

Linear	$y = \beta_0 + \sum_{n=1}^N \beta_n x_n$
Cobb-Douglas	$y = \beta_0 \prod_{n=1}^N x_n^{\beta_n}$
Quadratic	$y = \beta_0 + \sum_{n=1}^N \beta_n x_n + \frac{1}{2} \sum_{n=1}^N \sum_{m=1}^N \beta_{nm} x_n x_m$
Normalized quadratic	$y = \beta_0 + \sum_{n=1}^{N-1} \beta_n \left( \frac{x_n}{x_N} \right) + \frac{1}{2} \sum_{n=1}^{N-1} \sum_{m=1}^{N-1} \beta_{nm} \left( \frac{x_n}{x_N} \right) \left( \frac{x_m}{x_N} \right)$
Translog	$y = \exp \left( \beta_0 + \sum_{n=1}^N \beta_n \ln x_n + \frac{1}{2} \sum_{n=1}^N \sum_{m=1}^N \beta_{nm} \ln x_n \ln x_m \right)$
Generalized Leontief	$y = \sum_{n=1}^N \sum_{m=1}^N \beta_{nm} (x_n x_m)^{1/2}$
Constant Elasticity of Substitution (CES)	$y = \beta_0 \left( \sum_{n=1}^N \beta_n x_n^\gamma \right)^{1/\gamma}$

Source: Coelli, et al. (2005), pp. 211

For choosing proper functional form between different forms listed in Table 4.1, following properties are considered (Coelli, et al., 2005):

- 1) Flexibility: While a functional form has enough parameters to provide a first-order differential approximation and a second-order approximation to an arbitrary function at a single point, a second-order flexible functional form is preferred when other conditions are equal. However, increased flexibility may cause some econometric difficulties like multicollinearity owing to increased

parameters to estimate.

- 2) Linear in parameters: A functional form to estimate is usually used in a linear form. Most of Functional form listed in Table 4.1 can be transformed to linear equation by taking the logarithms of both sides.
- 3) Regular: Regularity is related to concavity of a function. A function convex in  $x$  satisfies homogeneous of degree  $k$  automatically or by imposing simple restrictions on the parameters that are sufficient for certain properties to be satisfied. If the production function is continuously differentiable, concavity implies all marginal products are non-increasing.
- 4) Parsimonious: It is better to choose the simplest functional form, giving adequate result, because including too many parameters or adapting functional form which does not fit to data pattern causes statistically insignificant improvements in sum of squared prediction errors, likelihood, or whatever criterion is employed.

Among the various functional forms, the Cobb-Douglas function and translog function are generally used as distance production function. Although the Cobb-Douglas form is flexible and easy to calculate, it doesn't satisfy regularity, not permitting to impose homogeneity, because of its restrictive elasticity of substitution and scale properties. The Cobb-Douglas function is not appropriate to a purely competitive industry because it is not concave (Coelli & Perelman, 2000)<sup>4</sup>. Therefore, in this research, a translog function is specified for the distance production functions.

In the case of  $M$  outputs and  $K$  inputs, the distance production function as the form of translog is described as follows (Coelli & Perelman, 2000):

$$\ln D_{Oi} = \alpha_0 + \sum_{m=1}^M \alpha_m \ln y_{mi} + \frac{1}{2} \sum_{m=1}^M \sum_{n=1}^M \alpha_{mn} \ln y_{mi} \ln y_{ni} + \sum_{k=1}^K \beta_k \ln x_{ki} + \frac{1}{2} \sum_{k=1}^K \sum_{l=1}^K \beta_{kl} \ln x_{ki} \ln x_{li} + \sum_{k=1}^K \sum_{m=1}^M \delta_{km} \ln x_{ki} \ln y_{mi} \quad i = 1, 2, \dots, N \quad (4.4)$$

---

<sup>4</sup> However, Coelli & Perelman (2000) points out that this is not a serious problem when the primary interest is just to obtain technical measures.

where,  $i$  denotes the  $i$ th firm in the sample. The frontier surface can be obtained if  $D_{Oi}$  is set to equal to 1, which implies the left hand side of Equation (4.4) is equal to zero. The restrictions on parameters are required to satisfy homogeneity of degree +1 in outputs are:

$$\sum_{m=1}^M \alpha_m = 1 \quad (4.5a)$$

and

$$\sum_{m=1}^M \alpha_{mn} = 0 \quad (m = 1, 2, \dots, M) \text{ and } \sum_{m=1}^M \delta_{km} = 0 \quad (k = 1, 2, \dots, K) \quad (4.5b)$$

And those required for symmetry are:

$$\alpha_{mn} = \alpha_{nm} \quad (m, n = 1, 2, \dots, M) \text{ and } \beta_{kl} = \beta_{lk} \quad (k, l = 1, 2, \dots, K) \quad (4.6)$$

Recalling the linear homogeneity of distance function, the output distance function is rewritten as  $D_o(x, \omega y) = \omega D_o(x, y)$ , for any  $\omega > 0$ . In order to impose the homogeneity constraint upon distance function, one of the outputs should be arbitrarily chosen, such as  $M$ th output, and set  $\omega = 1/y_M$ . Thus, the output distance function with the translog form can be described as follows:

$$\begin{aligned} \ln(D_{Oi}/y_{Mi}) = & \alpha_0 + \sum_{m=1}^{M-1} \alpha_m \ln y_{mi}^* + \frac{1}{2} \sum_{m=1}^{M-1} \sum_{n=1}^{M-1} \alpha_{mn} \ln \ln y_{mi}^* \ln y_{ni}^* + \sum_{k=1}^K \beta_k \ln x_{ki} \\ & + \frac{1}{2} \sum_{k=1}^K \sum_{l=1}^K \beta_{kl} \ln x_{ki} \ln x_{li} + \sum_{k=1}^K \sum_{m=1}^{M-1} \delta_{km} \ln x_{ki} \ln y_{mi}^* \quad i = 1, 2, \dots, N \end{aligned} \quad (4.7)$$

where,  $y_{mi}^* = y_{mi}/y_{Mi}$ . Equation (4.7) is summarised as follows:

$$\ln(D_{Oi}/y_{Mi}) = \text{TL}(x_{ki}, y_{mi}/y_{Mi}, \alpha, \beta, \delta) \quad i = 1, 2, \dots, N \quad (4.8)$$

or

$$\ln(D_{Oi}) - \ln(Y_{Mi}) = \text{TL}(x_{ki}, y_{mi}/y_{Mi}, \alpha, \beta, \delta) \quad i = 1, 2, \dots, N \quad (4.9)$$

Therefore, finally the equations above can be rewritten as Equation (4.10):

$$-\ln(Y_{Mi}) = \text{TL}(x_{ki}, y_{mi}/y_{Mi}, \alpha, \beta, \delta) - \ln(D_{Oi}) \quad i = 1, 2, \dots, N \quad (4.10)$$

## Stochastic Frontier Analysis: Estimating Technical Efficiency

The distance function form described above is a deterministic form, which ignores the effect of random shocks in the production process. Some groups of researchers introduced another random variable representing statistical noise to consider measurement errors and other sources of statistical noise (Coelli, et al., 2005). The model, including two types of error terms, which are statistical noise and inefficiency term, is called as a stochastic frontier model (SF model) and stochastic frontier analysis (SFA) is the method to estimate the parameters and inefficiency of the model. SF model was developed simultaneously by two groups of researchers, Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977). SFA is widely used in many previous studies that either analyse the efficiency of railway transport by estimating the production function (Coelli & Perelman, 2000; Lan & Lin, 2006), investigate the efficiency of yardstick regulation by estimating the cost function (Mizutani, et al., 2009), or estimate the cost efficiency of the UK railway (Kennedy & Smith, 2004). Equation (4.11) describes proposed model of single-output and multiple-input case:

$$y_i = f(x_i; \boldsymbol{\beta}, \alpha, \delta) \cdot \exp(v_i) \cdot \exp(-u_i) \quad (4.11)$$

where including a symmetric random error,  $v_i$ , which represents statistical noise. The random error  $v_i$  can be positive or negative, thus, statistical frontier outputs distribute below or above the deterministic part of the model,  $f(x_i; \boldsymbol{\beta}, \alpha, \delta)$ . Therefore, ' $f(x_i; \boldsymbol{\beta}, \alpha, \delta) \cdot \exp(v_i)$ ' is the stochastic production frontier (SPF). The deterministic part of the model is common to all producers, while  $\exp(v_i)$  is a producer-specific part and related to the effect of random shocks on each producer (Kumbhakar & Lovell, 2003). Another error term,  $u_i$  is a non-negative and associated with the technical inefficiency. Since  $u_i$  illustrates the technical efficiency, equation (4.11) is rewritten as follows:

$$y_i = f(x_i; \boldsymbol{\beta}, \alpha, \delta) \cdot \exp(v_i) \cdot \exp(-u_i) = f(x_i; \boldsymbol{\beta}, \alpha, \delta) \cdot \exp(v_i) \cdot TE_i \quad (4.12)$$

In figure 4.3, the inputs and outputs of two firms are plotted and the curve which represents the deterministic part of the product frontier model in equation (4.12). Two

firms produce the outputs  $(y_1, y_2)$  using the input of each firm  $(x_1, x_2)$ . If there were no inefficiency effects  $(u_1, u_2 = 0)$  and only statistical noise  $(v_1, v_2)$ , the frontier outputs of firm 1 is above the deterministic part of the product frontier model  $(v_1 < 0)$  and those of firm 2 is below the deterministic part of the product frontier model  $(v_2 > 0)$ . However, considering the existence of inefficiency effects, the outputs of two firms lie below the deterministic part of the frontier because inefficiency effects and the sum of statistical noise and inefficiency effect are negative. Generally, observed outputs tend to lie below the deterministic part of the frontier, while unobserved frontier outputs are evenly distributed above and below of that of the frontier. However, to place observed outputs above deterministic part, the statistical noise should be positive and larger than the inefficiency effect  $(v_i - u_i > 0)$  (Coelli, et al., 2005).

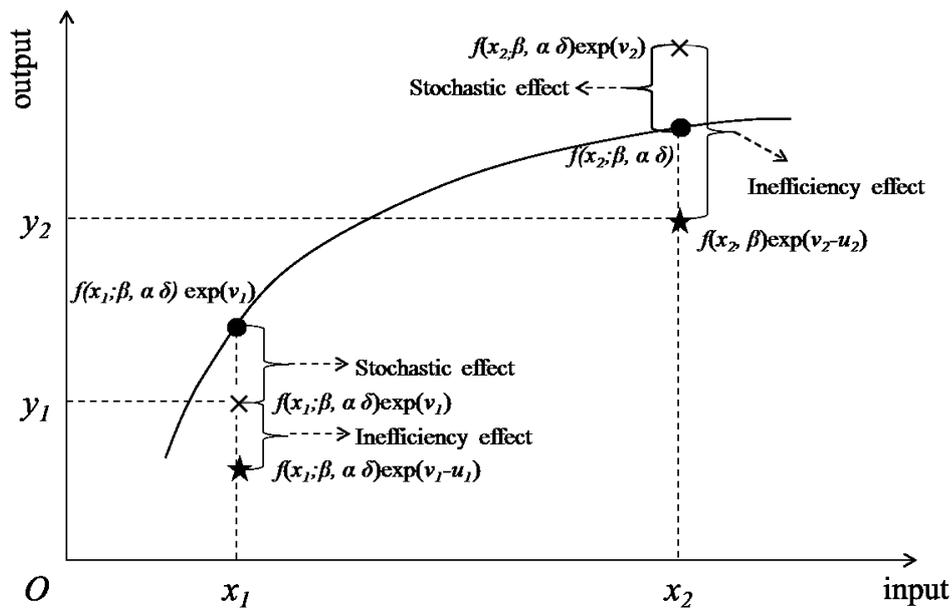


Figure 4.3 The Stochastic Frontier Analysis

Source: Coelli, et al. (2005), pp.244

The technical efficiency, the last term of inefficiency effect in equation (4.12), is output-oriented measure in this study and is defined as the ratio of observed output to the corresponding stochastic frontier output (Coelli, et al., 2005):

$$TE_i = \frac{y_i}{f(x_i; \beta, \alpha, \delta) \cdot \exp(v_i)} = \exp(-u_i) \quad (4.13)$$

Technical efficiency measure,  $TE_i$ , takes a value between zero and one. If a firm

achieves a fully-efficient production,  $TE_i$  equals to one.  $TE_i$  is a producer-specific measure because it is characterised by  $\exp(v_i)$  which varies across the firms. Technical efficiency can be predicted by estimating the parameters of the SPF model.

On the other hand, intercept is biased downwards because it does not provide predictions of produce-specific technical efficiency, although OLS provides consistent estimate for slope coefficient in equation (4.11) or (4.12). However, OLS can be used as simple test to check the presense of technical inefficiency. If technical inefficiency does not exist in the data ( $u_i = 0$ ), then the error term only consists of random noise ( $\varepsilon_i = v_i$ ) and it is symmetric. Thus, the assumption of SF model of the data is wrong. However, if technical inefficiency exists in the data ( $u_i > 0$ ), the error terms have two componets ( $\varepsilon_i = v_i - u_i$ ), and is negatively skewed<sup>5</sup>. Thus, if the negative skewness in OLS residuals is confirmed, it is the evidence of presence of technical inefficiency in the data and it makes sense to proceed to the estimation of a SPF (Kumbhakar & Lovell, 2003). But, due to complexity of test of OLS residuals, the likelihood ratio test of full model (SF model) and nested model (OLS) is generally used in the analysis using statistical software packages like STATA, LIMDEP, and SHAZAM.

Again, OLS cannot be used to predict the measure of technical efficiency, but, corrected ordinary least squares (COLS) can be solution to correct the bias in the intercept term. The function is fitted in two steps by COLS: 1) regressing  $y_i$  on  $f(\cdot)$  by using the OLS to interpret the unobserverble term, and 2) adjusting intercept by adding the largest negative OLS residual to it, thereby the function bounds the observed points from above, not passing through the centre of them. However, the best solution to estimate SPF is to extract  $v_i$  and  $u_i$  from predictions of  $\varepsilon_i$  for each producers, and this requires to make some distributional assumptions concerning two error terms. The model is estimated by maximum likelihood (ML) because ML estimators have many desirable large sample properties (Coelli, et al., 2005). As a result, the estimation of SPF is performed in two-step procedure: 1) estimating the slope parameters using OLS, and 2) estimating the intercept and the variances of the

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<sup>5</sup> See Appendix 4.B regarding how to check the existence of technical inefficiency using OLS residuals.

two error components by ML. Thus, distributional assumptions are used in the second step because it is used in the ML method (Kumbhakar & Lovell, 2003). As distributional assumptions of error terms, while it is assumed that statistical error term,  $v_i$ , is independently and identically distributed (iid) normal random variables with zero means and variances  $\sigma_v^2$ , half-normal, exponential, truncated normal, and gamma distribution are used as distributional assumptions of the technical efficiency term,  $u_i$  (see Appendix 4.A).

SPF and technical efficiency discussed above concern the cross-sectional data which does not consider change of the time. However, a panel data set contains more information than a cross-sectional data set. Thus, it is expectable that the panel data will moderate some of the strong distributional assumptions in cross-sectional data and enable to obtain more reliable estimates of technical efficiency than that of cross-sectional data, with more desirable statistical properties (Kumbhakar & Lovell, 2003). With regard to prediction of technical efficiency of panel data, several literature proposed the models in which inefficiency component is assumed to be time-invariant (Pitt & Lee, 1981; Battese & Coelli, 1988) and time-varying (Cornwell, et al., 1990; Kumbhakar, 1990; Battese & Coelli, 1992; Lee & Schmidt, 1993; Cuesta, 2000).

Given observations on a sample of  $N$  firms over  $T$  time periods, equation (4.11) can be redefined as follows:

$$y_{it} = f(x_{it}; \boldsymbol{\beta}, \alpha, \delta) \cdot \exp(v_{it}) \cdot \exp(-u_{it}) \quad (4.14)$$

Battese and Coelli (1988) define the firm specific technical efficiency which assumes that production technology is constant through time ( $u_{it} = u_i$ ). The firm specific technical efficiency is the ratio of mean production of the firm, given its realised firm effect, to the corresponding mean production if the firm effect was zero.

$$TE_i = \frac{E(y_{it}^* | u_i, x_{it}, t = 1, 2, \dots)}{E(y_{it}^* | u_i = 0, x_{it}, t = 1, 2, \dots)} \quad (4.15)$$

Because they define technical efficiency term is random variable, distributional assumptions are needed and assumed a truncated normal distribution ( $u_i \sim iid N^+(\mu, \sigma_u^2)$ ). They also define the equation of  $TE_i$  using conditional probability

density function (PDF) of  $u_i$ , which is the function of truncated normal distribution, and the equation is described as follows:

$$\widehat{TE}_i \equiv E\{\exp(-u_i) | q_i\} = \left[ \Phi\left(\frac{u_i^*}{\sigma^*} - \sigma^*\right) / \Phi\left(\frac{u_i^*}{\sigma^*}\right) \right] \exp\left\{\frac{\sigma^{*2}}{2} - u_i^*\right\} \quad (4.16)$$

where,  $\Phi(x)$  is the cumulative distribution function.

On the other hand, time-varying inefficiency assumes that technical inefficiency varies over time and takes the form as follows:

$$u_{it} = f(t) \cdot u_i \quad (4.17)$$

Battese and Coelli (1992) define the technical inefficiency,  $u_{it}$ , as follows:

$$u_{it} = \eta_{it} u_i = \{\exp[-\eta(t - T)]\} u_i, \quad t \in \vartheta(i); i = 1, 2, \dots, N \quad (4.18)$$

where,  $y_{it}$  and  $x_{it}$  are the outputs and inputs for the  $i$ th firm at the  $t$ th period of observation.  $v_{it}$ s are assumed to have normal distribution ( $v_{it} \sim iid N(0, \sigma_v^2)$ ) and  $u_{it}$ s are assumed to have non-negative truncated normal distribution ( $u_{it} \sim iid N(\mu, \sigma_u^2)$ ).  $\eta$  is an unknown scalar parameter. Equation (4.15) implies  $u_{it}$  can decrease or increase by the change of  $t$ , if  $\eta > 0$  or  $\eta < 0$ , respectively. Especially, if  $\eta = 0$ , technical efficiency remains constant regardless of change of time. In addition, as described in equation (4.15), technical efficiency must either increase at a decreasing rate ( $\eta > 0$ ), decrease at an increasing rate ( $\eta < 0$ ), or remain constant ( $\eta = 0$ ) owing to time parameter representing the behavior of the firm effects over time. Given the equation (4.14) and (4.15), the minimum-mean-squared-error predictor of technical efficiency of the  $i$ th firm at the  $t$ th period is described as follows:

$$TE_{it} = E[\exp(-u_{it}) | \varepsilon_i] = \left\{ \frac{1 - \Phi[\eta_{it} \sigma_i^* - (\mu_i^* / \sigma_i^*)]}{1 - \Phi(-\mu_i^* / \sigma_i^*)} \right\} \exp\left[-\eta_{it} \mu_i^* + \frac{1}{2} \eta_{it}^2 \sigma_i^{*2}\right] \quad (4.19)$$

where,  $\varepsilon_i$  is the  $(T_i \times 1)$  vector of  $\varepsilon_{it}$ s ( $\varepsilon_{it} = v_{it} - u_{it}$ );

$$\mu_i^* = \frac{\mu \sigma_v^2 - \eta_i' \varepsilon_i \sigma^2}{\sigma_v^2 + \eta_i' \eta_i \sigma^2}, \sigma_i^{*2} = \frac{\sigma_v^2 \sigma^2}{\sigma_v^2 + \eta_i' \eta_i \sigma^2} \quad (4.20)$$

where  $\eta_i$  represents the  $(T_i \times 1)$  vector of  $\eta_{it}$  and  $\Phi(\cdot)$  represents the distribution function for the standard normal random variable.

The mean technical efficiency of firms at the  $t$ th time period can be described as follows:

$$TE_t = E[\exp(-\eta_t u_i)], \text{ where } \eta_t = \exp[-\eta(t - T)] \quad (4.21)$$

Technical efficiency in equation (4.18) is obtained by integration with the density function of  $u_i$ :

$$TE_t = \left\{ \frac{1 - \Phi[\eta_t \sigma - (\mu/\sigma)]}{[1 - \Phi(-\mu/\sigma)]} \right\} \exp \left[ -\eta_t \mu + \frac{1}{2} \eta_t^2 \sigma^2 \right] \quad (4.22)$$

If the firm effects are fixed, the mean technical efficiency of firms in the industry is obtained by equation (4.22) by substitution of  $\eta_t = 1$ . Predictions of equation (4.19) and (4.22) are obtained by substituting parameters by ML estimators (Battese & Coelli, 1992). While time-invariant specification of Battese and Coelli (1988) is defined in terms of firm-specific explanatory variables, this time-varying inefficiency is not firm-specific estimate as describe in equation (4.22) (Battese & Coelli, 1993).

### Technical Inefficiency Effects

With estimaion of technical efficiency, explaining why inefficiency occurs in production process is the one of the important issues in stochastic frontier analysis and several approaches to estimate technical inefficiency effects were proposed (Kumbhakar, et al., 1991; Reifschneider & Stevenson, 1991; Huang & Liu, 1994; Battese & Coelli, 1995). Especially, Battese and Coelli (1995) proposed the two-stage approach, in which the technical inefficiency is predicted by estimating SPF at the first stage and the determinants of the model of technical inefficiency is estimated by regression at the second stage, for panel data and time-varying technical efficiency model. They assume technical inefficiency,  $u_{it}$ , predicted by SPF as dependent variable and the regression model consists of explanatory variables as following:

$$u_{it} = z_{it}\theta + \omega_{it} \quad (4.23)$$

where,  $z_{it}$  is a set of explanatory variables related to technical inefficiency and  $\theta$  is a set of coefficients of  $z_{it}$ .  $\omega_{it}$  is defined by the truncation of the normal distribution

with zero mean and variance,  $\sigma^2$ .  $u_{it}$  is obtained by truncation (at zero) of the normal distribution with mean,  $z_{it}$ , and variance,  $\sigma^2$ . The set of explanatory variables,  $z_{it}$ , can include some input variables in the SPF.

Thus, technical efficiency of production for the  $i$ -th firm at  $t$ -th observation is defined by equation (4.24):

$$TE_{it} = \exp(-u_{it}) = \exp(-z_{it}\theta - \omega_{it}) \quad (4.24)$$

Note that  $z_{it}\theta + \omega_{it} > z_{i't}\theta + \omega_{i't}$  for  $i \neq i'$  does not mean that  $z_{it'}\theta + \omega_{it'} > z_{i't'}\theta + \omega_{i't'}$  for  $t' \neq t$ . That is, ordering of firms in terms of technical efficiency may vary with time, as similar to time-varying inefficiency models.

## Summary

Accounting-based measures, related to financial returns, are widely used as proxies of the firm's performance in previous research, but, these traditional measures focus on the profitability, rather than the firm's capability transforming resources or strategic assets into core competencies. Diversified firms produce multiple outputs using multiple inputs and the productivity is varied with the firm. Therefore, the ability of a firm effectively combining resources, which it owns, can be measured by technical efficiency in the production process and a firm's activity, and producing outputs using inputs can be described using production function. Likewise, stochastic frontier analysis provides a framework estimating production function and predicting determinants of a firm's technical efficiency simultaneously.

While several functional forms are known as form of production function, Cobb-Douglas form and translog form are mostly used in the research, considering properties which production function should satisfy. To predict technical efficiency, two error terms, statistical noise and inefficiency term, are included in production function, and technical efficiency can be calculated by stochastic frontier analysis. With prediction of technical efficiency, containing set of explanatory variables and dependent variable represented by inefficiency terms, can be estimated to investigate what influences on inefficiency, and be described as the regression model.

## Appendix 4.A Distributional Assumptions of Error Terms<sup>6</sup>

Distributional assumptions are necessary to estimate the intercept and the variances of two error components using maximum likelihood. Because distributions of error terms is like to largely influence on sample mean efficiencies, the distributional assumptions should be chosen carefully. Although this section gives description of distributional assumptions focusing on the cross-sectional data model, all the assumptions can be applied to panel data stochastic frontier model.

### The Normal-Half Normal Model

Distribution assumptions for the model with a normal distribution on  $v_i$  and a half-normal distribution on  $u_i$  are described as follows:

- i  $v_i \sim \text{iid } N(0, \sigma_v^2)$
- ii  $u_i \sim \text{iid } N^+(0, \sigma_u^2)$  (nonnegative half normal)
- iii  $v_i$  and  $u_i$  are distributed independently of each other, and of the regressors

The normal-half normal model is widely used because it is relatively easy to derive the distribution of the sum of  $v$  and  $u$ . Aigner, Lovell and Schmidt (1977) used the normal-half normal model in their study to obtain ML estimates for the first time. They estimated parameters of the log-likelihood function for half-normal model in terms of  $\sigma^2 = \sigma_v^2 + \sigma_u^2$  and  $\lambda^2 = \sigma_u^2 / \sigma_v^2 \geq 0$ .  $\lambda = 0$  indicates no existence of technical inefficiency effects and all deviations from the frontier result from statistical noise<sup>7</sup>. The definitions of  $\sigma^2$  and  $\lambda^2$  are also applied to other distribution models. However, for  $\lambda^2$ , it is needed to beware of misinterpretation. Coelli, Rao, O'Donnell and Battese (2005) point out that  $\lambda^2$  is not the ratio of the variance of the technical inefficiency effects to the variance of the random noise, although we can confirm the existence

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<sup>6</sup> This section is mainly based on the book of Kumbhakar and Lovell (2003).

<sup>7</sup> The definition of  $\sigma^2$  and the check of existence of technical inefficiency effects by  $\lambda^2$  is also applicable other distributional models introduced in later part of this section.

of technical efficiency in data through value of  $\lambda^2$ .

Because  $u$  and  $v$  follow the normal (half normal) distribution, the density function of each error term can be written as follows:

$$f(u) = \frac{2}{\sqrt{2\pi}\sigma_u} \cdot \exp\left\{-\frac{u^2}{2\sigma_u^2}\right\} \quad (4.A.1)$$

$$f(v) = \frac{1}{\sqrt{2\pi}\sigma_v} \cdot \exp\left\{-\frac{v^2}{2\sigma_v^2}\right\} \quad (4.A.2)$$

Considering assumption that  $u$  and  $v$  are distributed independently, the joint density function of  $u$  and  $v$  is the product of each individual density function.

$$f(u, v) = \frac{2}{2\pi\sigma_u\sigma_v} \cdot \exp\left\{-\frac{u^2}{2\sigma_u^2} - \frac{v^2}{2\sigma_v^2}\right\} \quad (4.A.3)$$

Since  $\varepsilon = v - u$ , the joint density function<sup>8</sup> for  $u$  and  $\varepsilon$  can be rewritten as:

$$f(u, \varepsilon) = \frac{2}{2\pi\sigma_u\sigma_v} \cdot \exp\left\{-\frac{u^2}{2\sigma_u^2} - \frac{(\varepsilon + u)^2}{2\sigma_v^2}\right\} \quad (4.A.4)$$

By integrating  $u$  out of  $f(u, \varepsilon)$ , the marginal density function of  $\varepsilon$  is obtained.

$$\begin{aligned} f(\varepsilon) &= \int_0^{\infty} f(u, \varepsilon) du = \frac{2}{\sqrt{2\pi}\sigma} \cdot \left[1 - \Phi\left(\frac{\varepsilon\lambda}{\sigma}\right)\right] \cdot \exp\left\{-\frac{\varepsilon^2}{2\sigma^2}\right\} \\ &= \frac{2}{\sigma} \cdot \phi\left(\frac{\varepsilon}{\sigma}\right) \cdot \Phi\left(-\frac{\varepsilon\lambda}{\sigma}\right) \end{aligned} \quad (4.A.5)$$

where,  $\Phi(\cdot)$  and  $\phi(\cdot)$  are the standard normal cumulative distribution and density functions<sup>9</sup>.

Generally, in the normal-half normal distribution, the marginal density function of error terms is negatively skewed with negative mode (mean) because  $\sigma_u > 0$ . The distribution parameters  $\sigma$  and  $\lambda$  in equation (4.A.5) are estimated together with the intercept parameter and coefficients of explanatory variables. Therefore, it is desirable to conduct a statistical test of the hypothesis that  $\lambda = 0$ , using log likelihood

<sup>8</sup> The joint density function is also known as the likelihood function.

<sup>9</sup> The definitions of  $\Phi(\cdot)$  and  $\phi(\cdot)$  are commonly applied in the case of other distributions which delineated later of this section.

ratio test based on the chi-square statistics, to check the existence of technical inefficiency.

On the other hand, the marginal density function  $f(\varepsilon)$  is asymmetrically distributed with mean and variance,

$$E(\varepsilon) = -E(u) = -\sigma_u \sqrt{\frac{2}{\pi}},$$

$$V(\varepsilon) = \frac{\pi - 2}{\pi} \sigma_u^2 + \sigma_v^2 \quad (4. A. 6)$$

and, using equation (4.A.5), the log likelihood function of  $f(\varepsilon)$  is derived as follows:

$$\ln L = \text{constant} - I \ln \sigma + \sum_{i=1}^I \ln \Phi\left(-\frac{\varepsilon_i \lambda}{\sigma}\right) - \frac{1}{2\sigma^2} \sum_{i=1}^I \varepsilon_i^2 \quad (4. A. 7)$$

where,  $\varepsilon_i = v_i - u_i = \ln q_i - x_i' \beta$  by definition of production function. Equation (4.A.7) is called as the log likelihood function. Maximum likelihood estimates of all parameters can be obtained from maximising the log likelihood function, by simply taking first derivative with respect to  $\beta, \sigma$  and  $\lambda$ , and setting them to zero. However, the first-order conditions of equation (4.A.7) are nonlinear, and cannot be solved for  $\beta, \sigma$  and  $\lambda$ . Therefore, it is necessary to take an iterative optimisation procedure to maximise log likelihood function. The softwares such as STATA, LIMDEP, and SHAZAM parameterise the log-likelihood by taking different parameters each other.

After maximising log likelihood function, the technical efficiency of each producer is obtained from the conditional distribution of  $u_i$  given  $\varepsilon_i$ . Jondrow, Lovell, Materov and Schmidt (1982) derived conditional mean of  $u_i$  using the conditional distribution of  $u$  given  $\varepsilon$ :

$$E(u_i | \varepsilon_i) = \mu_{*i} + \sigma_* \left[ \frac{\phi(-\mu_{*i}/\sigma_*)}{1 - \Phi(-\mu_{*i}/\sigma_*)} \right] = \sigma_* \left[ \frac{\phi(\varepsilon_i \lambda / \sigma)}{1 - \Phi(\varepsilon_i \lambda / \sigma)} - \left( \frac{\varepsilon_i \lambda}{\sigma} \right) \right] \quad (4. A. 8)$$

and,

$$M(u_i | \varepsilon_i) = \begin{cases} -\varepsilon_i \left( \frac{\sigma_u^2}{\sigma^2} \right) & \text{if } \varepsilon_i \leq 0 \\ 0 & \text{otherwise} \end{cases} \quad (4. A. 9)$$

where,  $\mu_* = -\varepsilon\sigma_u^2/\sigma^2$  and  $\sigma_*^2 = \sigma_u^2\sigma_v^2/\sigma^2$ . Generally,  $E(u_i|\varepsilon_i)$  is more widely used than  $M(u_i|\varepsilon_i)$  to obtain the technical efficiency.

The technical efficiency of each producer can be obtained from:

$$TE_i = \exp\{-\hat{u}_i\} \quad (4. A. 10)$$

where  $\hat{u}_i$  can be either  $E(u_i|\varepsilon_i)$  or  $M(u_i|\varepsilon_i)$ . Estimates of technical efficiency for each producer can be also obtained using conditional mean of exponential value of  $-u_i$  given  $\varepsilon_i$  (Battese & Coelli, 1988).

$$TE_i = E(\exp\{-u_i\}|\varepsilon_i) = \left[ \frac{1 - 1 - \Phi(\sigma_* - \mu_{*i}/\sigma_*)}{1 - \Phi(-\mu_{*i}/\sigma_*)} \right] \cdot \exp\left\{-\mu_{*i} + \frac{1}{2}\sigma_*^2\right\} \quad (4. A. 11)^{10}$$

The estimates gained by equation (4.A.10) and equation (4.A.11) are different each other because  $\exp\{-E(u_i|\varepsilon_i)\}$  and  $E(\exp\{-u_i\}|\varepsilon_i)$  are not equal. However, Kumbhakar and Lovell (2003) argue that the estimate of equation (4.A.11) is preferred to (4.A.10), particularly when  $u_i$  is not close to zero, because (4.A.11) is closer to definition of technical efficiency, which is the ratio of observed output to maximised output, than (4.A.10), given produce-specific part of stochastic production output,  $\exp\{v_i\}$ , which captures the effect of random shocks on each producer.

### The Normal-Exponential Model

The distributional model for  $u_i$  and  $v_i$  can be extended as introducing new distributional assumption to  $u_i$ .

- i  $v_i \sim iid N(0, \sigma_v^2)$
- ii  $u_i \sim iid$  exponential
- iii  $v_i$  and  $u_i$  are distributed independently of each other, and of the regressors

As described in the assumptions above, the assumptions for  $v_i$  and distributional relationship between  $u_i$  and  $v_i$  are not changed. Thus, it is only needed to define the density functions of  $u_i$  newly.

<sup>10</sup> This is basically same with the equation (4.16), although in equation (4.A.11)  $\mu$  is used to obtain technical efficiency, instead of  $u$ .

$$f(u) = \frac{1}{\sigma_u} \cdot \exp\left\{-\frac{u}{\sigma_u}\right\} \quad (4. A. 12)$$

The joint density function of  $u$  and  $v$  is product of their individual density functions.

$$f(u, v) = \frac{1}{\sqrt{2\pi}\sigma_u\sigma_v} \cdot \exp\left\{-\frac{u}{\sigma_u} - \frac{v^2}{2\sigma_v^2}\right\} \quad (4. A. 13)$$

Equation (4.A.13) can be rewritten as the joint density function of  $u$  and  $\varepsilon$ :

$$f(u, \varepsilon) = \frac{1}{\sqrt{2\pi}\sigma_u\sigma_v} \cdot \exp\left\{-\frac{u}{\sigma_u} - \frac{1}{2\sigma_v^2}(u + \varepsilon)^2\right\} \quad (4. A. 14)$$

Thus, the marginal density function of  $\varepsilon$  is,

$$f(\varepsilon) = \int_0^{\infty} f(u, \varepsilon) du = \left(\frac{1}{\sigma_u}\right) \cdot \Phi\left(-\frac{\varepsilon}{\sigma_v} - \frac{\sigma_v}{\sigma_u}\right) \cdot \exp\left\{\frac{\varepsilon}{\sigma_u} + \frac{\sigma_v^2}{2\sigma_u^2}\right\} \quad (4. A. 15)$$

The marginal density function  $f(\varepsilon)$  is asymmetrically distributed with mean and variance.

$$\begin{aligned} E(\varepsilon) &= -E(u) = -\sigma_u \\ V(\varepsilon) &= \sigma_u^2 + \sigma_v^2 \end{aligned} \quad (4. A. 16)$$

Although the shape of the normal-exponential distribution is determined by  $\sigma_u$  and  $\sigma_v$ ,  $f(\varepsilon)$  is negatively skewed with negative mean, same as the normal-half normal model. The distribution collapses to a negative exponential distribution as  $\sigma_u/\sigma_v$  increases, while it converges to a normal distribution as  $\sigma_v/\sigma_u$  increases. The log likelihood function of a sample of  $I$  producers is:

$$\ln L = \text{constant} - I \ln \sigma_u + I \left(\frac{\sigma_v^2}{2\sigma_u^2}\right) + \sum_{i=1}^I \ln \Phi(-A) + \sum_{i=1}^I \frac{\varepsilon_i}{\sigma_u} \quad (4. A. 17)$$

where,  $A = -\tilde{\mu}/\sigma_v$  and  $\tilde{\mu} = -\varepsilon - (\sigma_v^2/\sigma_u)$ . The log likelihood function can be maximised by simply taking first derivative with respect to  $\beta, \sigma$  and  $\lambda$ , and setting them to zero.

Technical efficiency of each producer can be obtained from either the mean or the mode of the conditional distribution of  $u$ . The conditional distribution  $f(u|\varepsilon)$  is distributed as  $N^+(\tilde{\mu}, \sigma_v^2)$ , thus, mean and mode can be described as follows:

$$E(u_i|\varepsilon_i) = \tilde{\mu}_i + \sigma_v \left[ \frac{\phi(-\tilde{\mu}_i/\sigma_v)}{\Phi(\tilde{\mu}_i/\sigma_v)} \right] = \sigma_v \left[ \frac{\phi(A)}{\Phi(-A)} - A \right]$$

$$M(u_i|\varepsilon_i) = \begin{cases} \tilde{\mu}_i & \text{if } \tilde{\mu}_i \leq 0 \\ 0 & \text{otherwise} \end{cases} \quad (4. A. 18)$$

Same as the normal-half normal model, both  $E(u_i|\varepsilon_i)$  and  $M(u_i|\varepsilon_i)$  can be used to predict producer-specific estimates of technical efficiency by substituting into equation (4. A. 10) or (4. A. 11).

### The Normal-Truncated Normal Model

The normal-truncated normal model assumes that  $u$  follows normal distribution same as the normal-half normal model, although  $u$  has a nonzero mode and is truncated below at zero. The distributional assumptions are described as follows:

- i  $v_i \sim \text{iid } N(0, \sigma_v^2)$ .
- ii  $u_i \sim \text{iid } N^+(\mu, \sigma_u^2)$  (nonnegative half normal)
- iii  $v_i$  and  $u_i$  are distributed independently of each other, and of the regressors

As mentioned above, an additional parameter  $\mu$  is included to the distributional assumptions, thus, the truncated normal distribution model allows more flexible representation of the pattern of efficiency in the data.

The density function  $f(v)$  is same with the normal-half normal model, thus, the truncated normal density function for  $u \geq 0$  is:

$$f(u) = \frac{1}{\sqrt{2\pi}\sigma_u\Phi(\mu/\sigma_u)} \cdot \exp\left\{-\frac{(u-\mu)^2}{2\sigma_u^2}\right\} \quad (4. A. 19)$$

where,  $\mu$  is the mode of the normal distribution, which is truncated below at zero. If  $\mu = 0$ ,  $f(u)$  converges to the half normal density function.

The joint density function of  $u$  and  $v$  is product of their individual density functions.

$$f(u, v) = \frac{1}{2\pi\sigma_u\sigma_v\Phi(\mu/\sigma_u)} \cdot \exp\left\{-\frac{(u-\mu)^2}{2\sigma_u^2} - \frac{v^2}{2\sigma_v^2}\right\} \quad (4. A. 20)$$

The joint density of  $u$  and  $\varepsilon$  is,

$$f(u, \varepsilon) = \frac{1}{2\pi\sigma_u\sigma_v\Phi(\mu/\sigma_u)} \cdot \exp\left\{-\frac{(u-\mu)^2}{2\sigma_u^2} - \frac{(\varepsilon+u)^2}{2\sigma_v^2}\right\} \quad (4. A. 21)$$

The marginal density of  $\varepsilon$  is,

$$\begin{aligned} f(\varepsilon) &= \int_0^\infty f(u, \varepsilon) du = \frac{1}{\sqrt{2\pi}\sigma_u\Phi(\mu/\sigma_u)} \cdot \Phi\left(\frac{\mu}{\sigma\lambda} - \frac{\varepsilon\lambda}{\sigma}\right) \cdot \exp\left\{-\frac{(\varepsilon+u)^2}{2\sigma^2}\right\} \\ &= \frac{1}{\sigma} \cdot \phi\left(\frac{\varepsilon+u}{\sigma}\right) \cdot \Phi\left(\frac{\mu}{\sigma\lambda} - \frac{\varepsilon\lambda}{\sigma}\right) \cdot \left[\Phi\left(\frac{\mu}{\sigma_u}\right)\right]^{-1} \end{aligned} \quad (4. A. 22)$$

where  $\sigma = (\sigma_u^2 + \sigma_v^2)^{1/2}$  and  $\lambda = \sigma_u/\sigma_v$ . The marginal density function  $f(\varepsilon)$  is asymmetrically distributed with mean and variance,

$$\begin{aligned} E(\varepsilon) &= -E(u) = -\frac{\mu a}{2} - \frac{\sigma_u a}{\sqrt{2\pi}} \cdot \exp\left\{-\frac{1}{2}\left(\frac{\mu}{\sigma_u}\right)^2\right\} \\ V(\varepsilon) &= \mu^2 \frac{a}{2} \left(1 - \frac{a}{2}\right) + \frac{a}{2} \left(\frac{\pi - a}{\pi}\right) \sigma_u^2 + \sigma_v^2 \end{aligned} \quad (4. A. 23)$$

where  $a = [\Phi(\mu/\sigma_u)]^{-1}$ . Although the normal-truncated normal distribution model contains additional parameter,  $\mu$ , compared to other models, it is also negatively skewed with negative mode (mean) like other distributions. The log likelihood function of a sample of  $I$  producers is,

$$\ln L = \text{constant} - I \ln \sigma - I \ln \Phi\left(\frac{\mu}{\sigma_u}\right) + \sum_{i=1}^I \ln \Phi\left(\frac{\mu}{\sigma\lambda} - \frac{\varepsilon_i\lambda}{\sigma}\right) - \frac{1}{2} \sum_{i=1}^I \left(\frac{\varepsilon_i + \mu}{\sigma}\right)^2 \quad (4. A. 24)$$

where,  $\sigma_u = \lambda\sigma/\sqrt{1 + \lambda^2}$ . The log likelihood function can be maximised by simply taking first derivative with respect to  $\beta$ ,  $\sigma$  and  $\lambda$ , and setting them to zero.

Technical efficiency of each producer can be obtained from either the mean or the mode of the conditional distribution of  $u$ . The conditional distribution  $f(u|\varepsilon)$  is distributed as  $N^+(\tilde{\mu}_i, \sigma_*^2)$ , thus, mean and mode can be described as follows:

$$\begin{aligned} E(u_i|\varepsilon_i) &= \sigma_* \left[ \frac{\tilde{\mu}_i}{\sigma_*} + \frac{\phi(\tilde{\mu}_i/\sigma_*)}{1 - \Phi(-\tilde{\mu}_i/\sigma_*)} \right] \\ M(u_i|\varepsilon_i) &= \begin{cases} \tilde{\mu}_i & \text{if } \tilde{\mu}_i \leq 0 \\ 0 & \text{otherwise} \end{cases} \end{aligned} \quad (4. A. 25)$$

Same as the normal-half normal model, both  $E(u_i|\varepsilon_i)$  and  $M(u_i|\varepsilon_i)$  can be used to

predict producer-specific estimates of technical efficiency by substituting into equation (4.A.10). If equation (4.A.11) is applied, the technical efficiency of each producer is written as follows.

$$TE_i = E(\exp\{-u_i\} | \varepsilon_i) = \frac{1 - \Phi[\sigma_* - (\tilde{\mu}_i/\sigma_*)]}{1 - \Phi(-\tilde{\mu}_i/\sigma_*)} \cdot \exp\left\{-\tilde{\mu}_i + \frac{1}{2}\sigma_*^2\right\} \quad (4.A.26)$$

which converges to the equation proposed by Battese and Coelli (1988) in the normal-half normal distribution model when  $\mu = 0$ .

### The Normal-Gamma Model

The normal-gamma distribution model was introduced by Greene (1980) and Stevenson (1980). This model is defined by generalising the normal-exponential model, assuming that  $u$  follows a gamma distribution. Therefore, the distributional assumptions are:

- i  $v_i \sim \text{iid } N(0, \sigma_v^2)$ .
- ii  $u_i \sim \text{iid gamma}$
- iii  $v_i$  and  $u_i$  are distributed independently of each other, and of the regressors

While the exponential distribution is a single-parameter distribution which has only scale parameter, the gamma distribution allows two parameters which are scale and shape parameter for  $u_i$ . In other words, the exponential distribution is a special case of gamma distribution. Thus, the gamma distribution model is appropriate to represent flexible pattern of technical efficiency.

Because the density function  $f(v)$  is same with that of other distributional modes, the gamma density function  $f(u)$  for  $u \geq 0$  is,

$$f(u) = \frac{u^m}{\Gamma(m+1)\sigma_u^{m+1}} \cdot \exp\left\{-\frac{u}{\sigma_u}\right\}, \quad m > 1 \quad (4.A.27)$$

If  $m = 0$ , the gamma density function has the same density function with the exponential distribution. For  $-1 < m < 0$  the shape of gamma density is same with the that of an exponential density, while the point concentrating density becomes farther away from zero as  $m$  increases. The joint density function of  $u$  and  $v$  is,

$$f(u, v) = \frac{u^m}{\Gamma(m+1)\sigma_u^{m+1}\sqrt{2\pi}\sigma_v} \cdot \exp\left\{-\frac{u}{\sigma_u} - \frac{v^2}{2\sigma_v^2}\right\} \quad (4.A.28)$$

and the joint density function of  $u$  and  $\varepsilon = v - u$  is,

$$f(u, \varepsilon) = \frac{u^m}{\Gamma(m+1)\sigma_u^{m+1}\sqrt{2\pi}\sigma_v} \cdot \exp\left\{-\frac{u}{\sigma_u} - \frac{(\varepsilon + u)^2}{2\sigma_v^2}\right\} \quad (4.A.29)$$

Thus, the marginal density function of  $\varepsilon$  is,

$$\begin{aligned} f(\varepsilon) &= \int_0^\infty f(u, \varepsilon) du \\ &= \frac{\sigma_v^m}{\Gamma(m+1)\sqrt{2\pi}\sigma_u^{m+1}} \cdot \exp\left\{\frac{\varepsilon}{\sigma_u} + \frac{\sigma_v^2}{2\sigma_u^2}\right\} \cdot \int_w^\infty (t-w)^m \exp\left\{-\frac{t^2}{2}\right\} dt \end{aligned} \quad (4.A.30)$$

where  $w = (\varepsilon/\sigma_v) + (\sigma_u/\sigma_v) \cdot f(\varepsilon)$  is asymmetrically distributed, with mean and variance,

$$\begin{aligned} E(\varepsilon) &= -E(u) = -(m+1)\sigma_u \\ V(\varepsilon) &= \sigma_v^2 + (m+1)\sigma_u^2 \end{aligned} \quad (4.A.31)$$

Because the marginal density function in equation (4.A.30) includes an integral term, Beckers and Hammond (1987) proposed a closed-form of the function.

$$\begin{aligned} f(\varepsilon) &= \frac{1}{\Gamma(m+1)\sqrt{2\pi}\sigma_u^{m+1}\sigma_v} \cdot \exp\left\{-\frac{\varepsilon^2}{2\sigma_v^2}\right\} \\ &\quad \cdot \int_0^\infty u^m \exp\left\{-\frac{u}{\sigma_u} - \frac{u\varepsilon}{\sigma_v^2} - \frac{u^2}{2\sigma_v^2}\right\} du \end{aligned} \quad (4.A.32)$$

where the integral

$$\int_0^\infty u^m \exp\left\{-\frac{u}{\sigma_u} - \frac{u\varepsilon}{\sigma_v^2} - \frac{u^2}{2\sigma_v^2}\right\} du = J(m, \sigma_u, \sigma_v, \varepsilon)$$

is known as a closed-form of density function. Thus, the log likelihood function of  $f(\varepsilon)$  can be defined as follows:

$$\ln L = \text{constant} - I \ln \Gamma(m+1) - (m+1)I \ln \sigma_u - I \ln \sigma_v$$

$$- \frac{1}{2\sigma_v^2} \sum_{i=1}^I \varepsilon_i^2 + \sum_{i=1}^I \ln J_i(m, \sigma_u, \sigma_v, \varepsilon)$$

$$\begin{aligned}
&= \text{constant} - I \ln \Gamma(m+1) - (m+1)I \ln \sigma_u + I \left( \frac{\sigma_v^2}{2\sigma_u^2} \right) \\
&\quad + \sum_{i=1}^I \frac{\varepsilon_i}{\sigma_u} + \sum_{i=1}^I \ln \Phi \left[ -\frac{(\varepsilon_i + \sigma_v^2/\sigma_u)}{\sigma_v} \right] + \sum_{i=1}^I \ln h(m, \varepsilon_i)
\end{aligned} \tag{4.A.33}$$

where  $h(m, \varepsilon_i) = E[z^m | z > 0, \varepsilon_i]$  and  $z = N[-(\varepsilon_i + \sigma_v^2/\sigma_u), \sigma_v^2]$ .

Technical efficiency of each producer can be obtained from either the mean or the mode of the conditional distribution of  $u$ . The conditional distribution function  $f(u|\varepsilon)$  is distributed as  $N^+(\tilde{\mu}_i, \sigma_*^2)$ , and mean and mode can be described as follows:

$$\begin{aligned}
E(u_i|\varepsilon_i) &= \tilde{\mu}_i + \sigma_* \left[ \frac{\phi(-\tilde{\mu}_i/\sigma_*)}{1 - \Phi(-\tilde{\mu}_i/\sigma_*)} \right] \\
M(u_i|\varepsilon_i) &= \begin{cases} \tilde{\mu}_i & \text{if } \tilde{\mu}_i \geq 0 \\ 0 & \text{otherwise} \end{cases}
\end{aligned} \tag{4.A.34}$$

The producer-specific technical efficiency can be gained by substituting  $E(u_i|\varepsilon_i)$  and  $M(u_i|\varepsilon_i)$  into  $TE_i = \exp\{-\hat{u}_i\}$ . An alternative estimator which is provided by the minimum squared error estimate can also be used to obtain the estimates of producer-specific technical efficiency by substituting equation (4.A.34) into  $TE_i = \exp\{-\hat{u}_i\}$ . Another estimate of producer-specific technical efficiency by Battese and Coelli (1988) is written as follows:

$$TE_i = E(\exp\{-u_i\} | \varepsilon_i) = \frac{1 - \Phi[\sigma_* - (\tilde{\mu}_i/\sigma_*)]}{1 - \Phi(-\tilde{\mu}_i/\sigma_*)} \cdot \exp\left\{-\tilde{\mu}_i + \frac{1}{2}\sigma_*^2\right\} \tag{4.A.35}$$

## Appendix 4.B Specification Test and Skewness in Inefficiency Term<sup>11</sup>

The validity of stochastic frontier specification of the model can be checked by the likelihood ratio test, constructed based on the log-likelihood values of the OLS and the stochastic frontier model. However, specification test using the likelihood ratio can be conducted after building and estimating the model. Before determining the model specification, an OLS residual test provides helpful information whether the stochastic frontier specification is appropriate for the data.

An OLS residual test is proposed by Schmidt and Lin (1984) and is adequate as pre-test of the model before the ML estimation, because the test statistic is not difficult to calculate. Stochastic production frontier function contains composed error term  $v_i - u_i$ , and  $v_i - u_i$  is negative because technical inefficiency term  $u_i$  is a non-negative and  $v_i$  follows the normal distribution with the zero value of the mean. It can be expected that the residuals from the corresponding OLS estimation shows negative skewness if the data fits stochastic frontier specification. Thus, the null hypothesis of the test is that there is no skewness in the data. If the sign of estimated skewness is negative, the null hypothesis is rejected and the existence of the one-sided error is supported. To test the skewness of OLS residuals, a sample-moment based statistics should be calculated;

$$\sqrt{b_1} = \frac{m_3}{m_2\sqrt{m_2}} \quad (4. B. 1)$$

where,  $m_2$  and  $m_3$  are the second and the third sample moments of the OLS residuals. Each moment of a random variable  $x$  is defined as follows:

$$m_2 = \frac{\sum(x - \bar{x})^2}{n}, \quad m_3 = \frac{\sum(x - \bar{x})^3}{n} \quad (4. B. 2)$$

$\widehat{\sqrt{b_1}} < 0$  implies that the OLS residuals are skewed to the left and stochastic frontier

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<sup>11</sup> This section is based on the book of Kumbhakar, Wang and Horncastle (2015)

specification is preferred to OLS. The distribution of  $\sqrt{b_1}$  is tabulated in a number of literature including D'Agostino and Pearson (1973).

On the other hand, Coelli (1995) suggests a modified form of the test discussed above. He focuses on that negative skewness comes from the negative value of third moment ( $m_3$ ). Thus, he proposes the test of whether the third moment is greater than or equal to zero. Under the null hypothesis of no skewness, the third moment of OLS residuals is asymptotically distributed as a normal random variable with mean 0 and variance  $6m_2^3/N$ . Thus, the statistics is defined as follows:

$$M3T = \frac{m_3}{\sqrt{6m_2^3/N}} \quad (4. B. 3)$$

The statistics is asymptotically distributed as a standard normal random variable. Significance of the statistics is decided by the critical value of normal distribution.

## 5. Efficiency of Diversification Strategies of the Private Railway Companies in Japan

PRCs in Japan have diversified into various businesses including railway business, focusing on the businesses utilising their assets, such as terminal building and land along railway lines. Diversification strategy is also one of the most remarkable features of railway industry in Japan. In this chapter, by estimating production function of diversified PRCs in Japan and predicting their technical efficiency, this study aims to investigate the effect of diversification strategies on the firm's technical efficiency, focusing on the use of relatedness and the firm's strategic background.

### Analytical Premise

Although this study reviewed the econometric frameworks and techniques for the structure of multiple output production in chapter 4, single output production functions are the beginnings describing production technology of the firm and multiple output models are derived and expanded from those for single output. However, single output model considers only aggregate output of the firm. Multiple output production function allows to interpret relationship between various outputs. For example, partial differential coefficients of logarithm of each output ( $\partial \ln y_M / \partial \ln y_m^*$ ) describe the shadow share or contribution of this output ( $y_m^*$ ) relative to normalising output,  $y_M$ , and the coefficients of interaction term of outputs ( $\alpha_{mn} = (\partial \ln y_M / \partial \ln y_m^*) / \partial \ln y_n^*$ ) represent the change in relative share of  $y_m^*$  from a change in output  $y_n^*$  (Paul & Nehring, 2005). The relationship between transportation segment, including railway business, and other diversified business is the one of the important points which this study focuses on. Thus, it is expected that multiple output function gives some insights for production system of diversified PRCs.

On the other hand, multiple output production system can be described by cost functions, as well as production function discussed above. In order to estimate cost function of the firm, information on input prices is needed, but, it is difficult to obtain

input prices for labour, assets and other intermediate inputs from the disclosed financial statements, although labour price may be calculated by dividing labour costs by the number of employees and rate of depreciation can be used as proxy of asset price. In fact, technical efficiency assumes that producers aim to maximise outputs as minimising waste of input uses. In addition, producers have high objective of maximisation of outputs at minimum cost, not just pursuing to avoid waste, and this is associated with cost efficiency. However, to predict cost efficiency by estimation of cost function, economic behavioural objective, such as cost minimisation, is needed to be added to provide additional characterisations of the structure of production technology, as well as information on the prices of the inputs and the outputs (Kumbhakar & Lovell, 2003). PRCs seek to minimise costs as private enterprise, but it is difficult to conclude that they are motivated to minimise cost in railway business because regulation on safety of railway service. In addition, this study focuses on the capabilities transferring owned resources to core competencies which are associated with the firm's future growth, rather than improving profitability which may be accomplished by cost minimisation. For such a reason, this study focuses on the firm's behaviour seeking the efficient use of its assets and resources to deploy diversification strategies, rather than achieving minimising cost. Thus, considering the relationship among diversified businesses, and the status of transportation segment as the firm's core business, multiple output production function is adopted to describe production technology of Japanese PRCs.

## **Hypothesis**

Although many researchers have investigated the relationship between diversification strategies and the firm's performance so far, most of these studies focus on the financial performance by adapting accounting-based measure, thereby overlooking core competence which exist beyond high profitability. In addition, diversification strategies of Japanese PRCs have some different aspects compared to that of manufacturing firms, focused firms operating single industry and non-regulated firms. Therefore, it is more appropriate to compare efficiencies among

railway companies using internal benchmarking.

This study has argued that the firm can improve capability combining its resources and assets effectively through deploying diversification strategies, thereby acquiring competitive advantages which enable it to be differentiated from competitors. As pointed out by previous literature, however, excessive expansion of diversified business is costly because it is hard to match its own resources or assets to new products or service and some resources, such as strategic assets represented by experience, knowledge, and know-how, is hard to be traded inside a firm. Therefore,

*Hypothesis 1: The broad extent of diversification cannot secure high efficiency of the firm.*

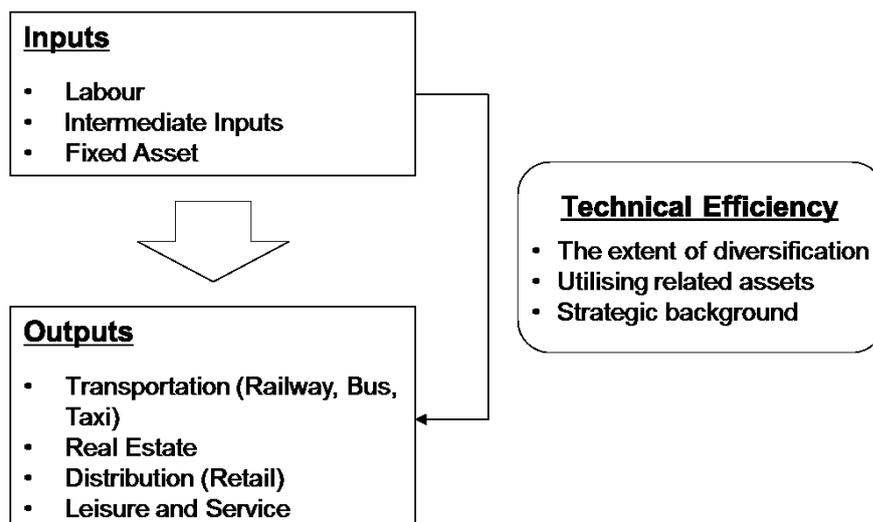
In addition, this study has emphasised importance of utilisation of related tangible and intangible assets in employing diversification strategies. As Shoji (2001) pointed out, in the case of in-house level, it is difficult to determine some diversified business or segment as vertical or relatedness because standardised rule to classify segment doesn't exist, while there is no doubt that railway business is the core business of PRCs. In the case of group-level diversification, defining vertical and related business is more complicated than the case of in-house level, because various businesses are included in one segment, in spite of the different contents of each business. For example, real estate segment contains both housing development in the area along the railway line and real estate agency in the area where the railway service of the firm is not operated, although the features of each business are not same in terms of verticality and relatedness. Nevertheless, in classifying the type of diversification, Yoshida (1986) and Shoji (2001) define that real estate business is close to related business. Shoji (2001) also argues that the managers of distribution business emphasis the importance of utilising terminals and main stations in survey of group-level diversification strategies of five PRCs in the Kansai region, although they recognise the necessity to be independent from railway business. Therefore,

*Hypothesis 2: Deploying diversification strategies focusing on the real estate and distribution (retail) business which utilise the*

*firm's assets more related to railway business positively influence on technical efficiency of the firm.*

This study has argued that increase of the extent of diversification causes technical inefficiency by hindering the process of sharing resources and assets. As discussed in the research of Shoji and Killeen (2001), minor PRCs which operate railway business in inferior demand condition diversify into various businesses like major PRCs. The history of diversification strategies of major PRCs is quite long, as mentioned above, thus, it can be assumed that they have accumulated plentiful experience and establish dominant logic to utilise their strategic assets and to control strategic variety, thereby minimising negative effect of expanding diversification strategies (Prahalad & Bettis, 1986). Therefore,

*Hypothesis 3: Although expansion of the extent of diversification is likely to decrease technical efficiency of the firm, major PRCs may overcome inefficiency by experience and dominant logic which are to utilise strategic assets and to control strategic variety.*



*Figure 5.1 Concept of Estimation of Production Function of Japanese PRCs*

## Data and Variables

This study focuses on the diversified PRCs that provide services like distribution (retail), leisure, and real estate in addition to transportation services. The PRCs, providing only transportation services and operating only freight and sightseeing railway are not included in the empirical analysis. Although, three JR companies were privatised in 1986 and have been considered as private operators, they are excluded from the sample because they operate intercity high-speed railway unlike other PRCs and have different strategic background<sup>12</sup> from other PRCs. The sample includes 34 diversified PRCs which consist of 15 major PRCs and 18 minor PRCs from 2000 to 2012 fiscal years. As a result, 442 observations are included in the sample. The data is gathered from the NIKKEI Financial Quest database and eol corporate information database, which contain information about the consolidated financial statements published by each company.

Previous studies on estimation of production function of the firm define inputs as capital and labour. The variables generally used for capital and labour, are fixed assets and the number of employees (Baek, 2004), capital stock and production worker hours (Schoar, 2002), as well as total physical capital and wage bill (Piesse & Thirtle, 2000). Although the output using capital and labour is value-added, value-added production function is hardly applicable to PRCs because they mostly diversify into service industry<sup>13</sup>. Therefore, to estimate production function focused on the sales, it is desirable to include intermediate inputs, which are typically subtracted out in a value-added production function, in order to control correlation between input levels and the unobserved productivity process (Levinsohn & Petrin, 2003). Because operating costs include selling, general and administrative expenses, and labour cost,

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<sup>12</sup> As mentioned in chapter 2, three JR companies in Honshu area were formed by privatisation in 1986. Owing to the privatisation, they started with huge assets and high-speed intercity railway (Shinkansen). This background causes many differences in contents of diversification strategies.

<sup>13</sup> In previous studies of manufacturing firm (e.g. auto producers), value-added (Chen, et al., 2015) or value-added per employee (Lieberman & Dhawan, 2005) are defined as output variable, thus, only input variables for capital and labour are needed.

it is used as proxy for intermediate inputs and labour<sup>14</sup>. Thus, this study uses the book value of fixed assets as the variable for capital and operating costs as the variable for intermediate inputs and labour. For output variables, net sales (Baek, 2004) and firm sales (Nesta, 2008) are used to estimate production function of the firm in previous research. Therefore, it seems reasonable to use the sales of each segment as multiple-output variables. However, each PRC classifies business segment by own rules because of absence of standardised rules in the present accounting standards. To standardise segment categories, different segments of each PRC are regrouped into four categories: transportation, real estate, distribution and others (i.e. leisure and service, etc.). Each category is considered as the main diversified business of PRCs by previous research (Killeen, 1999; Shoji, 2001; Kamata & Yamauchi, 2010).

The inefficiency model is specified with the following explanatory variables: diversification index, the ratio of sales of real estate and distribution to total sales and major PRC dummy. Herfindahl index ( $DI = 1 - \sum s_i^2$ ,  $s_i$  = the share of the  $i$ th segment from the firm's total sales) is included to describe the extent of diversification (Geringer, et al., 2000; Miller, 2006; Goddard, et al., 2008). Although there are many differences between major and minor PRCs, such as operating region, scale of diversification, and contents of diversified businesses, the sample includes both major and minor PRCs. Therefore, dummy variable for major PRCs is included to investigate differences in diversification strategies between major and minor. Major PRC dummy equals to one if the firm is classified into sixteen major PRCs. With regard to explanatory variables of inefficiency model, as well as variables related to diversification and form of the firm, the effect of regulation, corporate governance and financial leverage are of concern to efficiency, considering their role as external monitoring. However, in this study, the effect of diversification strategies and form of the firm are only considered, because the prior purpose of this study is to investigate the relationship between diversification strategies and inefficiency, and the model

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<sup>14</sup> Although some research proposes the use of capital investment as proxy of intermediate inputs (Olley & Pakes, 1996), Levinsohn and Petrin (2003) refer that it is difficult to define universal proxy for intermediate inputs and the choice of proxy depends on the details of data.

may not be converged if too many variables are included in the model. Therefore, the final model estimated in this study as follows:

$$\begin{aligned}
-\ln(\text{TR})_{it} = & \alpha_0 + \alpha_1 \ln(\text{RE}/\text{TR})_{it} + \alpha_2 \ln(\text{RT}/\text{TR})_{it} + \alpha_3 \ln(\text{OT}/\text{TR})_{it} + \beta_1 \ln(\text{FA})_{it} \\
& + \beta_2 \ln(\text{OC})_{it} + \alpha_{11} \cdot \frac{1}{2} \cdot [\ln(\text{RE}/\text{TR})_{it}]^2 + \alpha_{22} \cdot \frac{1}{2} \cdot [\ln(\text{RT}/\text{TR})_{it}]^2 \\
& + \alpha_{33} \cdot \frac{1}{2} \cdot [\ln(\text{OT}/\text{TR})_{it}]^2 + \beta_{11} \cdot \frac{1}{2} \cdot \ln(\text{FA})_{it}^2 + \beta_{22} \cdot \frac{1}{2} \cdot \ln(\text{OC})_{it}^2 \\
& + \alpha_{12} \cdot \frac{1}{2} \cdot \ln(\text{RE}/\text{TR})_{it} \cdot \ln(\text{RT}/\text{TR})_{it} + \alpha_{13} \cdot \frac{1}{2} \cdot \ln(\text{RE}/\text{TR})_{it} \cdot \ln(\text{OT}/\text{TR})_{it} \\
& + \alpha_{23} \cdot \frac{1}{2} \cdot \ln(\text{RT}/\text{TR})_{it} \cdot \ln(\text{OT}/\text{TR})_{it} + \beta_{12} \cdot \frac{1}{2} \cdot \ln(\text{FA})_{it} \cdot \ln(\text{OC})_{it} \\
& + \delta_{11} \cdot \ln(\text{FA})_{it} \cdot \ln(\text{RE}/\text{TR})_{it} + \delta_{12} \cdot \ln(\text{FA})_{it} \cdot \ln(\text{RT}/\text{TR})_{it} \\
& + \delta_{13} \cdot \ln(\text{FA})_{it} \cdot \ln(\text{OT}/\text{TR})_{it} + \delta_{21} \cdot \ln(\text{OC})_{it} \cdot \ln(\text{RE}/\text{TR})_{it} \\
& + \delta_{22} \cdot \ln(\text{OC})_{it} \cdot \ln(\text{RT}/\text{TR})_{it} + \delta_{23} \cdot \ln(\text{OC})_{it} \cdot \ln(\text{OT}/\text{TR})_{it} \\
& + v_{it} - u_{it}
\end{aligned} \tag{5.1}$$

$$u_{it} = \theta_0 + \theta_1 \cdot (\text{DI}) + \theta_2 \cdot (\text{DI}) \cdot (\text{MJ}) + \theta_2 \cdot (\text{rRET}) \tag{5.2}$$

All variables are deflated by the 2005 GDP deflator. Table 1 illustrates the detail of data and descriptive statistics.

*Table 5.1 Descriptive Statistics*

	Variables	Mean	Std. Dev.	Min	Max
Outputs (million Yen)	TR (Transportation)	75279	96245	1	482429
	RE (Real estate)	29898	42544	1	191428
	RT (Distribution)	80250	125540	1	678239
	OT (Others)	70655	105811	1	677833
Inputs (million Yen)	FA (Fixed assets)	415312	541085	1	2172927
	OC (Operating costs)	222745	292474	1	1315036
Inefficiency model	DI (Diversification index)	0.5688	0.1743	0	0.7501
	rRET (The ratio of real estate and distribution)	0.3377	0.2274	0	0.8145
	MJ (Dummy for major PRCs)	0.4412	0.4971	0	1

### Specification Tests

Although it is desirable to conduct the specification tests of the model before the estimation, the tests are usually conducted to examine the specification of the models after the estimation as a way of confirmation. In this study, two specification tests are

conducted. These are tested by imposing restrictions on the model and using the likelihood ratio static ( $\lambda$ ) to determine the significance of the restrictions. The likelihood ratio statistic is described as follows:

$$\lambda = -2\{\ln[L(H_0)] - \ln[L(H_1)]\} \quad (5.3)$$

where  $\ln[L(H_0)]$  and  $\ln[L(H_1)]$  are the values of the log likelihood function under null ( $H_0$ ) and alternative ( $H_1$ ) hypotheses.

First, the existence of technical inefficiency is tested to check the validity of model as stochastic frontier. The null hypothesis is that technical inefficiency effects do not exist in the production system of PRCs, thus, it indicates that the distribution of residuals is not one-sided. According to hypothesis, likelihood ratio (LR) test can be constructed based on the log-likelihood values of the OLS (restricted) and the stochastic frontier (unrestricted) model. Proposed hypothesis is that  $\sigma_u^2 = 0$ , and the degree of freedom is one because only one parameter,  $\sigma_u^2$ , is restricted in the test. By comparing the test static with the critical values of the distribution (see, Kodde and Palm (1986)), the result shows whether the null hypothesis can be rejected or not (Kumbhakar, et al., 2015). Second, the test of functional form is also conducted. Considering the principle of parsimony, less restrictive translog form is chosen if the null hypothesis that Cobb-Douglas form is adequate is rejected. Although Cobb-Douglas form is easy to estimate and interpret and requires estimation of a few parameters, it is simplistic to analyse the production structure of multiple firms at the same time, because Cobb-Douglas form assumes that all firms have the same production elasticities and that substitution elasticities equal to one. Table 5.2 illustrates the results of specification tests.

*Table 5.2 The results of specification tests*

<p>1. Existence of inefficiency  <math>H_0</math>: The significant inefficiency doesn't exist (<math>\sigma_u^2 = 0</math>).  <math>H_1</math>: The significant inefficiency exists (<math>\sigma_u^2 \neq 0</math>).  Statistic: 219.51  Critical value: <math>\chi_{1,0.01}^2 = 5.412</math>  Reject null hypothesis at 1% significance.</p>
<p>2. Functional form  <math>H_0</math>: Cobb-Douglas output distance function (<math>\alpha_{mn}, \beta_{kl}, \delta_{km} = 0</math>).  <math>H_1</math>: Translog output distance function (At least one parameter <math>\neq 0</math>).  Statistic: 520.41  Critical value: <math>\chi_{15,0.01}^2 = 29.927</math>  Reject null hypothesis at 1% significance.</p>

As a result, the likelihood ratio is 219.51 in the test of the existence of inefficiency and null hypothesis of OLS is rejected at 1% level. Therefore, SF specification can be applicable. In addition, the likelihood ratio is 520.41 in the test of functional form and the null hypothesis of Cobb-Douglas form is rejected at 1% level. Thus, it is proved that translog is a better model for the production system of PRCs in this study.

### **Empirical Analysis**

Since the sales of transportation segment are adopted as dependent variable, the adjusted sales of other segments are normalised by the sales of transportation to estimate the multi-output production frontier. The parameter estimates for the variable of output distance function are presented in Table 5.3.

Table 5.3 Parameter estimates of stochastic frontier production function and inefficiency model <sup>a</sup>

Variables	Model 1		Model 2		Model 3	
	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
RE ( $\alpha_1$ )	-0.1192***	0.0319	-0.1225***	0.0310	-0.1603***	0.0305
RT ( $\alpha_2$ )	0.0631***	0.0083	0.0603***	0.0081	0.0585***	0.0077
OT ( $\alpha_3$ )	0.3230***	0.0559	0.3403***	0.0545	0.3591***	0.0524
FA ( $\beta_1$ )	-0.0109	0.1085	-0.0503	0.1057	0.0459	0.1024
OC ( $\beta_2$ )	-0.6977***	0.1112	-0.6743***	0.1081	-0.7816***	0.1052
(RE) <sup>2</sup> ( $\alpha_{11}$ )	0.0366***	0.0029	0.0343***	0.0028	0.0300***	0.0027
(RT) <sup>2</sup> ( $\alpha_{22}$ )	0.0472***	0.0011	0.0460***	0.0011	0.0403***	0.0011
(OT) <sup>2</sup> ( $\alpha_{33}$ )	0.1032***	0.0143	0.0914***	0.0141	0.0911***	0.0136
(FA) <sup>2</sup> ( $\beta_{11}$ )	-0.0149	0.0224	-0.0302	0.0220	-0.0329	0.0212
(OC) <sup>2</sup> ( $\beta_{22}$ )	-0.0316	0.0354	-0.0551	0.0347	-0.0421	0.0334
RE × RT ( $\alpha_{12}$ )	-0.0161***	0.0023	-0.0148***	0.0022	-0.0141***	0.0021
RE × OT ( $\alpha_{13}$ )	-0.0353***	0.0125	-0.0202	0.0125	-0.0286**	0.0120
RT × OT ( $\alpha_{23}$ )	-0.0435***	0.0028	-0.0399***	0.0028	-0.0352***	0.0027
FA × OC ( $\beta_{12}$ )	0.0236	0.0557	0.0654	0.0548	0.0561	0.0528
FA × RE ( $\delta_{11}$ )	-0.0217***	0.0082	-0.0186**	0.0080	-0.0153**	0.0078
FA × RT ( $\delta_{12}$ )	-0.0084***	0.0029	-0.0099***	0.0028	-0.0067**	0.0028
FA × OT ( $\delta_{13}$ )	0.0515***	0.0162	0.0471***	0.0158	0.0499***	0.0150
OC × RE ( $\delta_{21}$ )	0.0489***	0.0091	0.0457***	0.0088	0.0436***	0.0085
OC × RE ( $\delta_{22}$ )	0.0280***	0.0033	0.0295***	0.0032	0.0231***	0.0032
OC × OT ( $\delta_{23}$ )	-0.0616***	0.0185	-0.0573***	0.0180	-0.0601***	0.0172
Constant ( $\alpha_0$ )	0.0000	0.0001	0.0001	0.0002	0.0001	0.0001
Inefficiency model						
DI ( $\theta_1$ )	1.0289***	0.0567	0.9669***	0.0561	1.0772***	0.0570
MJ × DI ( $\theta_2$ )			0.1170***	0.0246	0.1007***	0.0239
rRET ( $\theta_3$ )					-0.2731***	0.0333
Constant ( $\theta_0$ )	-0.1851***	0.0192	-0.1659***	0.0188	-0.1602***	0.0181
$\omega_u$	-5.8280***	0.0670	-5.8839***	0.0670	-5.9612***	0.0673
$\omega_v$	-22.2623***	5.8159	-22.1358***	7.9143	-22.6728***	7.4336
Obs.	442		442		442	
Log-likelihood	699.429		710.3432		729.1220	

<sup>a</sup>\*\*\*: significant at the 1% level; \*\*: significant at the 5% level; \*: significant at the 10% level

As well as estimated coefficients, elasticities of output and input variables give an important information to check specification of output distance function and economies of scale. Stochastic distance function satisfies monotonicity which is non-decreasing in  $y$  and non-increasing in  $x$ . To confirm monotonicity of the stochastic multi-output function, equation (4.10) can be rewritten as the function of  $\ln(D_{Oit})$ :

$$\ln(D_{Oit}) = \text{TL}(x_{kit}, y_{mit}/y_{Mit}, \alpha, \beta, \delta) + \ln(y_{Mit}) \quad i = 1, 2, \dots, N \quad (5.4)$$

By the properties of multiple output distance function, estimated function must be an increasing function of each output and a decrease function of each input. Regarding a Cobb-Douglas function, if the coefficients of input variables is greater than or equal to zero, the estimated function satisfies monotonicity. However, to a translog function, local monotonicity must be checked to confirm whether the estimated function satisfies monotonicity:  $\partial D_{Oi}/\partial y_{mi} = (\partial \ln D_{Oi}/\partial \ln y_{mi}) \cdot (D_{Oi}/y_{mi}) \geq 0$ , or equivalently  $\partial \ln D_{Oi}/\partial \ln y_{mi} \geq 0$  and  $\partial \ln D_{Oi}/\partial \ln x_{ki} \leq 0$  (Lan & Lin, 2006). Table 5.4 presents elasticities of output and input variables of each model.

*Table 5.4 Output and input elasticities*

		Elasticity		
		Model 1	Model 2	Model 3
Output	Real estate	0.1319	0.1281	0.1134
	Distribution	0.1766	0.1734	0.1516
	Others	0.2700	0.2728	0.2941
Input	Fixed assets	-0.0211	-0.0071	-0.0051
	Operating costs	-1.0208	-1.0166	-1.0162

For all models, the first partial derivatives of output variables are greater than zero and those of input variables are less than zero, therefore, the models are adequately estimated as satisfying monotonicity.

In addition, the sum of the elasticities of each input variable shows increase of output by increasing 1 percent in each input, similar to a returns to scale estimate from a production function. Elasticity for input,  $-\partial \ln D_{Oi}/\partial \ln x_{ki} = \partial \ln y_{Mi}/\partial \ln x_{ki}$ , represents the percent change in  $y_{Mi}$  by changing a 1 percent in  $x_{ki}$ . Therefore, the output-oriented distance function based scale economy measure is calculated by summing these elasticities (Färe & Primont, 1995).  $-\sum_k \partial \ln D_{Oi}/\partial \ln x_{ki} =$

$\sum_k \partial \ln y_{Mi} / \partial \ln x_{ki} > 1$  implies increasing returns to scale. In other words, increase in inputs results in output expansion (Paul & Nehring, 2005). In Table 5.4, the sum of elasticities for inputs is greater than 1, although it is negative value. However, considering the dependent variable of each model is the negative value of natural log of the sales of transportation, the negative value of the sum is not irrational, thus, it indicates slight increasing returns scale.

## Discussion

By estimating stochastic production function of PRCs and inefficiency model simultaneously, this study obtains implications of production system of PRCs and impact of diversification strategies on the firm's technical efficiency.

First of all, the output distance elasticities in Table 5.4 provide information about the share of each product in total output, and the output elasticity of arbitrary output, which is used to normalise (the sales of transportation in this research) other outputs, can be calculated by homogeneity of distance function (Newman & Matthews, 2006). Thus, the output elasticity,  $-\partial D_{Oi} / \partial y_{mi} = \partial y_{Mi} / \partial y_{mi}^*$ , implies the shadow value of  $y_{mi}$  relative to  $y_{Mi}$ . The input distance elasticities also reflect the share of each input to all inputs (Paul & Nehring, 2005; Newman & Matthews, 2006). The distance elasticity for transportation is 0.4215 (Model 1), 0.4257 (Model 2), and 0.4409 (Model 3). In all models, the distance elasticity for transportation is higher than that for other outputs. In addition, the input distance elasticity of operating costs which include labour cost and variable cost is higher than that of fixed assets in all models overwhelmingly. It means that transportation business still largely contributes to total production of Japanese PRCs and is placed as core business of PRCs. In addition, production greatly depends on labour and intermediate inputs to be needed to operation and large elasticity of operating costs reflects the characteristic of diversified businesses of PRCs which are concentrated in tertiary sector of industry that is labour intensive and is related to providing service. Lan and Lin (2006) argue that greater input elasticity of employees implies overstaffing in the railway transport industry and reducing employees can be essential strategy according to their analysis

which uses the number of passenger cars, freight cars, and employees as input variables. Thus, in the case of Japanese PRCs, improving operation system to cut operating costs may be critical to enhance technical efficiency.

The estimated coefficients of inefficiency model are main interest of this study. In inefficiency model, negative coefficient indicates positive relationship with technical efficiency because the dependent variable of inefficiency model is technical inefficiency,  $u_{it}$ , which indicates distance between production set and the curve of production frontier. The coefficient of diversification index is positive and statistically significant in all models, which implies that the extent of diversification is related to technical efficiency negatively. This result corresponds with previous studies which measure the firm's performance by accounting indices (e.g. return on equity) and market value (e.g. Tobin's  $q$ ). These previous studies report a neutral or negative relationship between the extent of diversification and performance (Montgomery, 1994). In this study, the type of diversification strategies based on Rumelt's method is not applied because of difficulties to classify related and unrelated business using currently disclosed financial data of Japanese PRCs. Nevertheless, Montgomery (1982) proves that continuous measure is highly related to categorical measure of Rumelt and it increases consistently as unrelatedness of type of diversification is increased (see also Montgomery & Wernerfelt (1988), Chatterjee & Wernerfelt (1991)). Thus, it is reasonable to regard higher diversification index as evidence of expansion of diversification strategies. In previous research of Japanese major PRCs, increase of diversification index is likely to correspond with expanding diversification strategies, and diversification index of the firm which is classified into unrelated is greater than 0.37 approximately (Shoji, 2001; Kamata & Yamauchi, 2010). With regard to relationship between diversification strategies and profitability of Japanese PRCs, Shoji (2001) points out that diversifying more than necessary can cause decline of profitability. Therefore, it is considered that expanding diversification strategies can negatively influence the firm's efficiency and hypothesis 1 is supported. Because related or dominant type firms, which diversify focusing on the businesses close to their main business, show the highest profitability in comparison of

diversification strategies and profitability, it is not surprise that high diversification is not associated with high efficiency.

Moreover, the coefficient of the ratio of the sales of real estate and distribution business to total sales is negative and statistically significant. This implies that increasing the proportion of real estate and distribution business in PRCs may contribute to improvement of efficiency. As mentioned before, although some PRCs deploy diversified business outside their operating region in which is the area along a railway line by the form of real estate agency and department store, land along a railway line and terminal building are still important assets for PRCs. Shoji (2001) assumes that real estate business is likely to be related vertically and technologically, considering that it exploits physical assets of railways (e.g. terminal building, land) and know-how accumulated by operating railway, although he investigates the case of diversification at the in-house level (division), not in group-level (subsidiary). As well as utilising assets and knowledge, large scale of development is still conducted around main station and terminal buildings (e.g. development of areas surrounding Umeda station by Hankyu-Hanshin holdings, development plan of Shinagawa station by Keikyu, redevelopment of Sibuya station and nearby area by Tokyu). Therefore, real estate business has relatedness with transportation business in terms of sharing tangible assets and knowledge. In addition, distribution business emphasises availability of terminal in city center and building of main station of railways (Shoji, 2001), and seeks to exploit synergy effect with railway and to capture railway passengers as their customers. PRCs are also motivated by exploiting brand image and trust derived from railway business and highly regard the importance of location in terminal building in center city and main station of railways (Shoji, 2001). Thus, distribution business can be considered as highly related business to transportation business. Therefore, negative and significant coefficient of the ratio of distribution and real estate businesses to total sales indicates that concentrating the firm's competence to its related business like distribution and real estate influences positively on efficiency and hypothesis 2 is also supported.

Interaction term of diversification index and dummy for major PRC is included to

investigate whether major PRCs overcome disadvantages resulting from expanding diversification beyond relatedness by examining hypothesis 3. Although increase of variety of diversified business is considered to be not efficient comparing to related diversification and major PRCs deploy businesses over various field, as mentioned before, it is expected that major PRCs may properly cope with difficulties from deploying new businesses because they have stronger dominant logic and more efficient organisational system to exploit their strategic assets than other PRCs, given their history and scale. In addition, while related diversification can achieve economies of scope by adopting cooperative organisational arrangements, expansion of the extent of diversified businesses can realise benefit of governance economies, which attenuate information disadvantages of stockholders and induce efficient allocation of capital and funds by exposing divisions to internal governance system, through adopting competitive organisational system (Hill, et al., 1992). However, the coefficient of interaction term is positive and statistically significant indicating negative impact to technical efficiency, and hypothesis 3 is not supported. This implies that negative effect of expanding the extent of diversification becomes greater for major PRCs. Major PRCs deploy not only traditional diversified businesses (real estate, distribution) but also new territory which the firm has not tried yet, such as insurance, consumer finance, and cable TV. In addition, geographical diversification of major PRCs has accelerated in recent years, as well as business diversification. For example, Tokyu corporation operates real estate agency in Kansai region and owns resort and leisure facilities in various places of country, beyond its original operating area. Business expansion into overseas is also one of the trends of diversification of major PRCs, although its proportion is not high. Seibu holdings operates "Hawaii segment" managing hotel and leisure business in Hawaii and Tokyu corporation undertakes real estate development in Australia. Likewise, major PRCs have extended their business area beyond traditional business sector which they have deployed and the area along the railway line. In other words, their competencies are widely dispersed over various businesses and major PRCs may not have enough dominant logic or appropriate organisational structure to control

competencies in expanding diversification. Therefore, based on the rich strategical assets like geographical conditions of terminals and main stations and business know-how resulting from diversification for a long time, it can be said that major PRCs should control expansion of diversification strategies as strengthening governance or establishing dominant logic to exploit resources to enhance efficiency.

## **Summary**

In this chapter, the quantitative analysis of effect of diversification strategies on the firm's technical efficiency is conducted by estimating production function of Japanese diversified PRCs using stochastic frontier analysis. The production function is defined as multiple output distance function and inefficiency model is also estimated using technical inefficiency as dependent variable simultaneously. To investigate what influence technical efficiency of Japanese PRCs, three hypotheses are proposed: 1) The broad extent of diversification cannot secure high efficiency of the firm; 2) Deploying diversification strategies focusing on the real estate and distribution business which utilise the firm's assets more related to railway business; 3) For major PRCs, negative effect of expansion of diversification strategies is attenuated considering their know-how and rich strategical assets, such as terminal building and railway demand, and dominant logic.

The sample includes 34 diversified PRCs which consist of 15 major PRCs and 18 minor PRCs from 2000 to 2012 fiscal year. As a result, 442 observations are obtained. The estimated model is defined by two input variables (the book value of fixed assets, operating costs) and four output variables (the sales of transportation, real estate, distribution, and others segment). The inefficiency model is specified with diversification index (Herfindahl index), the ratio of sales of real estate and distribution to total sales and major PRC dummy.

Empirical results indicate that diversified PRCs in Japan achieve economies of scope in deploying diversified businesses. It is also confirmed that transportation business still contributes to total production of Japanese PRCs and production greatly depends on labour and intermediate inputs to be needed to operation. In the

inefficiency model, the extent of diversification influences the technical efficiency negatively, while the ratio of the sales of real estate and distribution business to total sales is positively related to technical efficiency. The negative effect of the extent of diversification is amplified if the firm is major PRCs. By the estimation, like previous research using accounting-based measure as dependent variable, it is found that excessive diversification expanded into unrelated businesses is negatively related to performance expressed by technical efficiency. This is supported by the positive effect of the proportion of real estate and distribution business in PRCs. The tendency of diversification of major PRCs, expanding their businesses in unfamiliar place and new territory, affect technical efficiency negatively and this is confirmed by interaction term of the extent of diversification and dummy variable for major PRCs.

## Appendix 5.A Estimates of Parameters in the Translog Frontier Production Function

		OLS		Pooled SFA		Panel OLS (GLS)		Frontier (BC 88) <sup>15</sup>	
		Coef.	Std.err	Coef.	Std.err	Coef.	Std.err	Coef.	Std.err
RE	( $\alpha_1$ )	-0.1101***	0.0408	-0.1101***	0.0398	0.2352***	0.0477	0.2514***	0.0482
RT	( $\alpha_2$ )	0.0560***	0.0107	0.0560***	0.0104	0.0101	0.0132	0.0077	0.0138
OT	( $\alpha_3$ )	0.2273***	0.0716	0.2273***	0.0699	0.1894***	0.0646	0.1709***	0.0630
FA	( $\beta_1$ )	-0.2472*	0.1375	-0.2472*	0.1341	-0.4682***	0.1266	-0.4024***	0.1207
OC	( $\beta_2$ )	-0.5323***	0.1421	-0.5323***	0.1387	-0.2604**	0.1321	-0.3308***	0.1258
(RE) <sup>2</sup>	( $\alpha_{11}$ )	0.0260	0.0036	0.0260***	0.0035	-0.0051***	0.0032	0.0339***	0.0032
(RT) <sup>2</sup>	( $\alpha_{22}$ )	0.0515	0.0014	0.0515***	0.0013	0.0387***	0.0015	0.0377***	0.0014
(OT) <sup>2</sup>	( $\alpha_{33}$ )	0.1640	0.0180	0.1640***	0.0175	0.1457***	0.0155	0.1487***	0.0147
(FA) <sup>2</sup>	( $\beta_{11}$ )	0.0868	0.0281	0.0868***	0.0275	-0.0723**	0.0334	-0.0847***	0.0324
(OC) <sup>2</sup>	( $\beta_{22}$ )	0.0536	0.0453	0.0536	0.0442	-0.1629***	0.0460	-0.1678***	0.0439
RE × RT	( $\alpha_{12}$ )	-0.0030	0.0027	-0.0030	0.0027	-0.0051*	0.0028	-0.0051*	0.0029
RE × OT	( $\alpha_{13}$ )	-0.0443	0.0160	-0.0443***	0.0156	-0.0014	0.0137	-0.0101	0.0130
RT × OT	( $\alpha_{23}$ )	-0.0456	0.0035	-0.0456***	0.0035	-0.0463***	0.0031	-0.0454***	0.0030
FA × OC	( $\beta_{12}$ )	-0.1586	0.0709	-0.1586**	0.0692	0.2088***	0.0767	0.2266***	0.0738
FA × RE	( $\delta_{11}$ )	-0.0470	0.0105	-0.0470***	0.0102	-0.0167**	0.0085	-0.0111	0.0080
FA × RT	( $\delta_{12}$ )	-0.0184	0.0036	-0.0184***	0.0035	-0.0122***	0.0041	-0.0094**	0.0039
FA × OT	( $\delta_{13}$ )	0.0998	0.0207	0.0998***	0.0202	-0.0299*	0.0171	-0.0326**	0.0161
OC × RE	( $\delta_{21}$ )	0.0720	0.0115	0.0720***	0.0113	0.0100	0.0099	0.0023	0.0094
OC × RT	( $\delta_{22}$ )	0.0412	0.0041	0.0412***	0.0040	0.0330***	0.0045	0.0299***	0.0044
OC × OT	( $\delta_{23}$ )	-0.1049	0.0237	-0.1049***	0.0232	0.0364*	0.0203	0.0403**	0.0193
Constant	( $\alpha_0$ )	0.0035	0.0152	0.0041	0.0289	-0.0076	0.0192	0.3777***	0.1014
Insig2v				-5.3714***	0.0673				
Insig2u				-14.6227	93.0732				
Sigma								-4.2767***	0.2477
Gamma								2.4769***	0.2812
Mu								0.3886***	0.1031

<sup>15</sup> The estimates are calculated using the definition of technical efficiency of Battese and Coelli (1988).

## Appendix 5.B Test of Monotonicity

Monotonicity of production function indicates an increase function of each output and a decrease function of each input. Monotonicity can also be confirmed by the derivative of the function with respect to each input and normalised output variable. According to definition of monotonicity, the derivative of input variables is negative and that of normalised output variables is positive.

### (1) Checking monotonicity of output variables

$$\begin{aligned} \text{Real estate: } \frac{\partial \ln D_{Oit}}{\partial \ln RE_{it}} &= \alpha_1 + \alpha_{11} \cdot \ln(RE_{it}/TR_{it}) + \frac{1}{2} \cdot \alpha_{12} \cdot \ln(RT_{it}/TR_{it}) \\ &+ \frac{1}{2} \cdot \alpha_{13} \cdot \ln(OT_{it}/TR_{it}) + \delta_{11} \cdot \ln FA + \delta_{21} \cdot \ln OC \end{aligned}$$

$$\begin{aligned} \text{Distribution: } \frac{\partial \ln D_{Oit}}{\partial \ln RT_{it}} &= \alpha_2 + \alpha_{22} \cdot \ln(RT_{it}/TR_{it}) + \frac{1}{2} \cdot \alpha_{12} \cdot \ln(RE_{it}/TR_{it}) \\ &+ \frac{1}{2} \cdot \alpha_{23} \cdot \ln(OT_{it}/TR_{it}) + \delta_{12} \cdot \ln FA + \delta_{22} \cdot \ln OC \end{aligned}$$

$$\begin{aligned} \text{Others: } \frac{\partial \ln D_{Oit}}{\partial \ln OT_{it}} &= \alpha_3 + \alpha_{33} \cdot \ln(OT_{it}/TR_{it}) + \frac{1}{2} \cdot \alpha_{13} \cdot \ln(RE_{it}/TR_{it}) \\ &+ \frac{1}{2} \cdot \alpha_{23} \cdot \ln(RT_{it}/TR_{it}) + \delta_{13} \cdot \ln FA + \delta_{23} \cdot \ln OC \end{aligned}$$

### (2) Checking monotonicity of input variables

$$\begin{aligned} \text{Fixed assets: } \frac{\partial \ln D_{Oit}}{\partial \ln FA_{it}} &= \beta_1 + \beta_{11} \cdot \ln FA + \frac{1}{2} \cdot \beta_{12} \cdot \ln OC + \delta_{11} \cdot \ln(RE_{it}/TR_{it}) \\ &+ \delta_{12} \cdot \ln(RT_{it}/TR_{it}) + \delta_{13} \cdot \ln(OT_{it}/TR_{it}) \end{aligned}$$

$$\begin{aligned} \text{Operating costs: } \frac{\partial \ln D_{Oit}}{\partial \ln OC_{it}} &= \beta_2 + \beta_{22} \cdot \ln OC + \frac{1}{2} \cdot \beta_{12} \cdot \ln FA + \delta_{21} \cdot \ln(RE_{it}/TR_{it}) \\ &+ \delta_{22} \cdot \ln(RT_{it}/TR_{it}) + \delta_{23} \cdot \ln(OT_{it}/TR_{it}) \end{aligned}$$

## **6. Effects of Diversification Strategies on Investment in Railway Business of Private Railway Companies**

Diversification strategy of PRCs in Japan has generally been considered to be motivated and deployed in order to support the railway business. However, they make their own business portfolio including investment decisions and compete with other companies in some routes based on the market principle as private enterprises (Shoji, 2001). Although diversification strategies seem to play a key role in PRCs, it has not been investigated how they influence the railway business in terms of internal capital resource allocation for investment, focusing on the coexistence of railways, which are considered as to be public utilities, and diversified business. Previous research has noted the diversification strategies of Japanese PRCs, and investigated their effects, focusing on their contribution to the profitability of the railway business and to the entire company. However, most previous studies focus on the relationship between diversification and performance at the in-house level; finding research on how diversification strategies influence investment in the railway business for acquiring and upgrading assets is more challenging. Based on the foregoing, this chapter aims to investigate whether the internal capital of PRCs is utilised for investment in the railway business to improve railway services (e.g. route expansion and maintenance), considering the diversified business portfolio of the firm, and whether it is utilised to invest or improve other diversified businesses if it is not reinvested in the railway business. For these purposes, this research explores the investment decisions of PRCs from the perspective of internal capital markets, as well as free cash-flow and life-cycle theory, which are discussed in corporate finance, with reference to the case of Japanese PRCs in this chapter.

### **Two Roles of Japanese PRCs**

Japanese PRCs play two different roles: 1) as an operator providing public transportation services and 2) as a private enterprise pursuing profit maximisation.

Their diversification strategies are reasonable behaviour in terms of profit seeking, but we should not forget that they provide 'public' transportation services. In view of profitability, the transportation segments of diversified companies including bus and taxi modes as well as railways are profitable. The operating income of the transportation business can cover its own total costs and can generate sufficient additional capital and cash flow. Although cross-subsidies between transportation segments and other segments to make up for the operating loss are prohibited by law (Railway accounting rules), as private firms, they have the right to allocate their own funds as they see appropriate. Thus, the headquarters can transfer the capital resources of the transportation segments to other segments and subsidise it to invest in or improve the capital resources of other segments. On the contrary, as operator of public transportation, PRCs have an obligation to continue to offer high-quality services; indeed, they cannot cease the supply of transportation services because of exit regulations. Hence, they are obliged to invest in the railway business continually, as providers of a public service. Thus, it is important for them to balance the profitability and sustainability of transportation services. For example, they seek profit-making businesses to ensure the profitability of the entire company but also strategically invest in diversified businesses. The headquarters prioritise segment-level investment in this way. If the headquarters were concerned only about future profitability and the cost of capital motivated by profit-seeking, the transportation business would be neglected due to its limited ability to generate profitability.

### **Diversified Firms and Internal Capital Markets**

A firm's investment decision is generally based on the firm's internal financial environment and external financial factors. The resource allocation in diversified firms is different from that in focused firms because the former consist of many subsidiaries, divisions, or business units that operate various businesses. Internal capital markets (ICMs) allocate limited resources to the various divisions or segments inside the diversified company and the headquarters then have the authority to allocate (Stein, 1997; Peyer, 2002). Stein (1997) defines ICMs as channel allocating limited

resources to different uses inside a firm. In addition, Peyer (2002) regards ICMs as the mechanism by which headquarters allocates capital to the various divisions of firm. In diversified firms, each business unit or subsidiary strives to acquire more capitals than their competitive business units or subsidiaries under the existence of various and different business portfolios in the firm. Therefore, it is not too much to say that business units and subsidiaries in diversified firm are exposed to an internal competition due to investment interdependence (Stein, 1997).

ICMs are differentiated from external capital markets because of differences in information, incentives, asset specificity, control rights, or transaction costs (Lamont, 1997). While the providers of external capital, such as the bond market, the stock market, banks, and finance companies, mainly pay attention to the firm's value and growth opportunity which can be gained in external capital markets as return of investment, ICMs are formed in diversified firms in order to make investment decision and allocate capital resource efficiently. For investment decision, Lamont (1997) and Shin and Stulz (1998) argue that diversified firms are likely to overlook the value of investment represented by Tobin's  $q$ , which is a traditional market indicators, and this behaviour is largely different from that of focused firms.

Peyer (2002) points out that establishing ICMs gives a potential benefit of diversification with two main advantages. The first is that internal resource allocation can be more efficient than allocation by external capital markets because of the relaxed constraints on managerial behaviour and use of less strict monitoring systems (Jensen, 1986). The second advantage is that internal capital markets affect transactions with external capital markets by reducing information asymmetry, because the headquarters can reallocate investment across divisions based on a more precise estimation of value-maximising investment needs compared with external investors. If reallocating capital is based on productivity of a segment (Khanna & Tice, 2001; Maksimovic & Phillips, 2002) and if the headquarters do not pursue the incentive, but rather engage in acting in the interest of outside shareholders (Stein, 1997), the ICMs can facilitate efficient resource allocation. Stein (2003) also suggests two major benefits of ICMs, namely the 'more-money' effect and the

'smarter-money' effect. Generally, the 'smarter-money' effect is more emphasised as bright side of ICMs. The more-money effect is that diversified firms can acquire more total external financing than stand-alones, which is beneficial for the underinvestment problem. The smarter-money effect is based on the two premises: 1) the CEO in ICMs knows about the prospects of the firm's divisions well; 2) the CEO uses high-quality information to make reallocations across divisions. Likewise, well-informed managers can find valuable project to invest and allocate capital actively if he or she behaves in the interests of external shareholders. Stein (1997) insists that the managers are more likely to shift funds from low profitable project to the project which is expect to achieve high profitability and to have high future growth due to the smarter-money effect, when the firm operates in related lines of business. In addition, Shin and Stulz (1998) refers that ICMs enable diversifies firms to provide funds for profitable projects which the external capital markets would not be able to finance because of information asymmetries and agency costs.

On the contrary, some previous research emphasises the negative sides of ICMs which are the tendency towards overinvestment and misallocation of capital resources. Problem of overinvestment results from larger capital of diversified firms than that of focused firms due to the more-money effect ironically (Stein, 2003). Rather than tendency of overinvestment, however, the latter one, misallocation is more discussed in previous research. Lang and Stulz (1994), and Berger and Ofek (1995) argue that misallocation problem is related to low value of diversified firms on average compared to single-segment firms. Rajan, Servaes and Zingales (2000) synthesise three theoretical frameworks and propose their perspective to explain how the diversified firms show different behaviour to the focused firms and why value-destructive misallocation occurs in diversified firms.

With regard to the reason the diversified firms bahave different to the focused firms, first, efficient ICMs models is suggested, although the model insists that diversification creates value. The model assumes that ICMs, as pool of internally generated cash flow, can allocate resources to their best use, thus cannot explain misallocation to segments with poor opportunities (Stein, 1997; Matsusaka & Nanda,

2002). Second, agency cost model explains the potential investment distortions in diversified firms. As pointed out above, top managements in diversified firms have greater opportunities to initiate projects and plentiful resources to accomplish it because they are relatively easy to secure funds by the more money effect, compared to focused firms, and can utilise high-quality information to evaluate projects. However, plentiful cash pool and high-quality information lead managers to overinvestment, rather than rational decision to investment (Stulz, 1990; Matsusaka & Nanda, 2002). However, Rajan, Servaes and Zingales (2000) point out that the model is more adequate to explain generic overinvestment, which is motivated to strengthen CEO's power, instead of overinvestment coming from the CEO's decision. Thus, the model is difficult to explain why the internal misallocation of funds occurred rationally, because CEO should exploit all potential sources of value inside the firm as searching her/his rents only from overall pie. Third, influence cost models focus on the manager's behaviour in which his/her divisions have a dark future and he/she appeal to top management of the firm, thereby allocating resources to his/her division (Meyer, et al., 1992). While costs are incurred because of lobbying activities, it is hard to say that resources are misallocated to the divisions. Finally, Rajan, Servaes and Zingales (2000) propose their own model definitising explanation of misallocation of funds in diversified firms and value difference caused by misallocation. They assume that resource misallocation is caused by power-seeking and political principal inside the firm. Divisional managers are independent in choosing projects to invest and self-interested. Given the unclear incentive system, the divisional managers are reluctant to share some of the surplus created with the other division to keep bargaining power and political power, in spite of efficiency of invested other division's projects. As a result, they prefer the defensive investment that would benefit her/him more directly, especially when her/his resources and opportunities are much better than the other divisions.

### **Life-Cycle Theory and Free Cash-Flow Theory**

Free cash-flow theory, developed by Jensen (1986), refers to the problem of

agency costs and overinvestment. Before Jensen (1986), Mueller (1972) proposed life-cycle theory which focuses on the tendency of managers pursuing growth as the firm grows and matures. He assumed that a profit maximising firm aims to take advantage of a Schumpeterian innovation involving a new product, process, marketing or organisational technique (Grabowski & Mueller, 1975). A firm begins as exploiting an innovative idea of its creator. By exploiting creative and new idea, a firm comes into new areas which are closely related to its initial product line at first. It continues to expand its business and diversifies even further, thereby causing dispersion of its organisational structure and autonomy of divisions. As a result, a firm's efficiency decreases due to further expansion and it confronts with limitation of innovation (Mueller, 1972). Then, the firm experiences the decreased marginal returns from investment in the core business as a consequence of the life-cycle effects (also see Markides, 1995; Thompson, 1999). He also argued that firms operating core businesses in mature industries that generate enough cash to be reinvested are likely to aim to maximise growth, rather than profit and stockholder's welfare, and that internal capital makes investment funds available to managers. Especially, if a firm operating matured core business uses internal funds as the primary means of investment, it tends to invest in the project of low profitability. This, therefore, motivates managers to expand investment into different activities through conglomerate mergers.

While Mueller (1972) focused on maturity and limitation of continual innovation of core business to explain the diversifying behaviour utilising internal fund, Jensen (1986) assumes that overinvestment results from the firm's weak governance, and insists that free cash-flow tends to be invested in unprofitable expansion owing to managerial behaviour, which is characterised by the pursuit of rent. Thompson (1999) proposes constraints on managerial behaviour of the firm which influence on the level of corporate governance mechanisms: 1) threat of takeover, 2) threat of bankruptcy, 3) debt constraint, 4) shareholder voice, 5) product market competition, 6) stock market surveillance, and 7) management compensation mechanism. Jensen (1986) also argues that the conflict interest over payouts between corporate managers and

shareholders leads the managers to unprofitable diversification. According to Jensen (1986), managers are motivated to grow the size of a firm beyond the optimal size because it gives managers some incentives which are associated with growth of the managers' power by enhancing the control right of the resources (Murphy, 1985). The rewarding policy which is to promote middle managers also causes organisational bias towards growth (Baker, 1986). Due to a such reason as mentioned above, the managers deploy diversification strategies by mergers and takeovers using large free cash-flows, and it usually generates lower total gains, while the firm may achieve less waste of resources as investing them internally in unprofitable projects. Here, Jensen (1986) also emphasises that the firm operating in the industry, which generates large cash flows with few growth opportunities, tends to diversify, as Mueller (1972) discussed. However, he argues that this value-decreasing behaviour can be held back by the precommitment of cash flows generated by the core business to value-maximising projects. In addition to facilitating growth, corporate income fluctuations can further be attenuated by this investment expenditure (Amihud & Lev, 1981). Although the debt created in value-increasing takeovers by increased leverage has costs like bankruptcy costs, the threat of failure to debt service payments acts as monitoring force at the optimal debt-equity ratio that is the point where the marginal costs of debt offset the marginal benefits. By increased leverage, the firm should confront with the crisis to cut in expansion plans and to sell its divisions which are more valuable outside the firm. This process may lead the firm to consider strategies and optimal organisational structure continually.

### **Investment Opportunities and Cash Flow**

Investment opportunities and cash flows are critical factors, defining whether ICMS are efficient or not. Shin and Stulz (1998) define the ICMS to be efficient if 1) it regards the level of investment opportunities of the segment as the most important factor in the allocation of funds; 2) it makes the segment's investment less sensitive to its own cash flow as well as to other segments' cash flow; and 3) it allocates smaller funds to some segment with low investment opportunities when other segments with better

investment opportunities appear. Likewise, investment opportunities and cash flow are closely associated with efficiency of ICMs.

In traditional view of Modigliani and Miller (1958), the firm's investment is likely to depend on the profitability of its perceived investment opportunities measured by Tobin's  $q$ , and is not related to liquidity position or its leverage ratio. Several corporate finance studies have focused on Tobin's  $q$ , which is the value of the investment opportunity divided by the cost of the required investment (Maksimovic & Philips, 2008). Previous studies of this topic suggest that segments of diversified firms do not tend to respond properly to investment opportunities, although opportunities measured by the firm's Tobin's  $q$  should be firstly considered to decide the level of investment. This finding implies that diversified firms tend to underinvest in high opportunities, although they have a tendency to overinvest in low opportunities (Rajan, et al., 2000; Scharfstein & Stein, 2000). Previous research argues that investment distortion, which overlooks the signal represented by investment opportunities, such as Tobin's  $q$ , is caused by rent-seeking behaviour of the manager (Scharfstein & Stein, 2000; Matsusaka & Nanda, 2002; Chou, 2010). However, the evidence which ICMs respond to investment opportunities properly can be also found, given the condition of imperfect external capital markets (Matsusaka & Nanda, 2002; Kuppuswamy & Villalonga, 2010; Hovakiman, 2011).

Although investment opportunities have been considered the most critical factors influencing on the firm's investment decision, a firm also depends on cash flow of the segment. Much previous research suggests that a segment in diversified firms may rely both on its own cash flows and on those of other segments (Lamont, 1997; Shin & Stulz, 1998; Whited, 2001). A positive coefficient of the other segments implies transfer or subsidies among the segments (Shin & Stulz, 1998), with some previous studies investigating the effects of such transfers and subsidies (Rajan, et al., 2000; Khanna & Tice, 2001; Billett & Mauer, 2003). Furthermore, for highly diversified firms, segment investment is less sensitive to its cash flow compared to focused firms (Shin & Stulz, 1998). Cash flow becomes more influential in capital allocation when the firm faces with financing constraints (Shin & Stulz, 1998; Almeida, et al., 2004) and

industrial shock (Lamont, 1997; Khanna & Tice, 2001).

Based on the discussion above, previous studies suggest the following investment equation, including investing opportunities and cash flow of a segment and a firm (Lamont, 1997; Shin & Stulz, 1998; Maksimovic & Philips, 2008):

$$I_j = \beta \times q_j + \delta \times CF_j + \varphi \times CF_{\text{others}} + \gamma_i \times z_i + Dummy_{\text{year}} + Dummy_{\text{firm}} \quad (6.1)$$

where  $I_j$  is segment  $j$ 's capital expenditure,  $q_j$  is the Tobin's  $q$  of segment  $j$ ,  $CF_j$  is the cash flow of segment  $j$ ,  $CF_{\text{others}}$  is the cash flow of other segments except segment  $j$ , and  $z_i$  represents the other explanatory variables of each firm.

### **Data and Variables**

To focus on the investment policy of PRCs which operates in urban area and diversify widely, the sample includes 14 major PRCs<sup>16</sup>, which are diversified and which report segment information in their consolidated financial statements, and three JR companies (JR East, JR Central, JR West), which were privatised in 1986 and listed on the stock markets for the 1999-2012 fiscal years. Therefore, 17 companies are included in the sample. The data on all sample firms is obtained from the pool during 1999-2012 fiscal years since time-lagged data on decision timing is used, but the regressions cover from 2000 to 2012. As a result, 215 observations are included in the sample. The data are extracted from the NIKKEI Financial quest database, which contains data on the consolidated financial statements published by each company.

To investigate how the internal capital market affects investment in the transportation segment, the capital expenditures of the transportation segment are used as the dependent variable. Capital expenditures are normalised by the total assets of a firm in the previous year to represent investment sensitivity of a segment. As presented in equation (6.1), cash flow is a proxy of the stream of capital allocation in internal capital markets, and many studies estimating investment equations define

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<sup>16</sup> Two PRCs are excluded from the sample. Seibu Holdings is excluded because of incomplete data due to delisting and Tokyo Metro is excluded because it is not diversified.

cash flow as the sum of operating income and depreciation (Lamont, 1997; Shin & Stulz, 1998; Ahn, et al., 2006; Duchin, 2010). On the contrary, cash flow is also defined as the segment's after-tax cash flow (Billett & Mauer, 2003), net cash from operations minus dividends (Peyer, 2002), and free cash-flow (Faulkender, et al., 2012; Takami, 2012). The definition of cash flows influences the conclusion drawn on the efficiency of ICMs. Indeed, Shin and Stulz (1998) regress a segment's capital expenditures on an imputed segment's Tobin's  $q$ , the segment's own cash flow, and the cash flow of the firm's other segments and suggest that a positive coefficient estimate on the other segments' cash flow implies cross-subsidised capital expenditures between segments. However, Billett and Mauer (2003) support the efficiency of ICMs. In this research, a firm's cash flow is defined as its after-tax cash flow in line with Faulkender, Flannery and Hankins (2012) and Takami (2012), considering the characteristics of accounting system of Japanese firms, and is described as follows:

$$CF_{it}^k = \text{Operating profit}_{it}^k + \text{Depreciation}_{it}^k - (\text{Interest expense}_{it}^k + \text{Corporate tax}_{it}^k) \frac{\text{Assets}_{it}^k}{\sum_k \text{Assets}_{it-1}^k} - \text{Working capital}_{it}^k \frac{\text{Operating income}_{it}^k}{\sum_k \text{Operating income}_{it}^k} - \text{Capital expenditure}_{it}^k \quad (6.2)$$

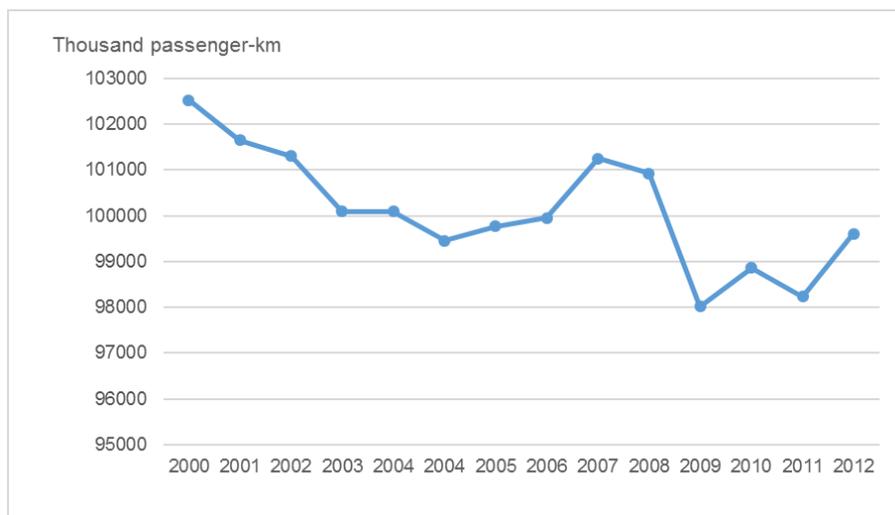


Figure 6.1 Change in the passenger KM of major PRCs in Japan

Source: Annual report on railway statistics, Japanese Ministry of Land, Infrastructure and Transport

Figure 6.1 shows the changes in the passenger KM of major PRCs in Japan from 2000 to 2012. While the passenger KM increased temporarily in 2007, it tended to decrease gradually over time. This study expects cash flow to lead headquarters in diversified firms to invest in growing business instead of the passenger-decreasing transportation segment, which has matured and thus had restricted profitability. In terms of the extra cash holdings of the firm, the cash flow of other segments also affects investment in the transportation segment because of the limited capital resources. Hence, this study uses the cash flow of the transportation segment and that of the other segments in the same period of investment and the variables are normalised by the total assets of a firm in the previous year.

As proxy of investment opportunities, Tobin's  $q$  has been widely used in the literature. Whited (2001), however, states that Tobin's  $q$  is an inadequate variable with which to control for investment opportunities. At the firm-level, Tobin's  $q$  is generally calculated by using disclosed financial data, as the ratio of the total market value of the firm (the sum of total stock market value and total liabilities) to the total asset value, while it is not observed directly at the segment level because the segments of diversified firms are not traded. Therefore, the median of the Tobin's  $q$ s of the focused firms are used in many previous literature, particularly based on a segment's three-digit industry SIC code in the case of U.S. However, Whited (2001) insists that a segment's Tobin's  $q$  tends to lie below the industry median when a diversification discount exists. Much of the empirical literature also suggests that investment opportunities of same-industry focused firms are not representative of those of the segments of diversified firms (Lang & Stulz, 1994; Berger & Ofek, 1995; Billett & Mauer, 2003; Villalonga, 2004). Moreover, most of empirical studies use data on U.S. manufacturing companies, which classify segments by using SIC codes, thus, it is easy to understand structure of diversified business. However, in Japan, segment classification is not based on SIC code or on the standardised rule, but rather on the decision of a firm's manager. This distinction implies that matching the segments of diversified and focused firms is difficult because various businesses are mixed in one segment in case, as is shown in the case of PRCs. In addition, there is a huge gap

between diversified major PRCs and focused other PRCs in the size of firm, due to difference in operating area and demand condition of railway business. Thus, using industry median Tobin's  $q$  like some previous research may distort investment opportunities of transportation segment of major PRCs. Given the difficulties and limitations mentioned above, Lang, Ofek and Stulz (1996) use a segment's ROA which is the ratio of operating income to segment assets, as a proxy of investment opportunities. In this vein, the segment ROA is also used as a variable of investment opportunities in this study.

For diversification strategies, the extent of diversification is also regarded to influence investment decisions (Shin & Stulz, 1998; Maksimovic & Phillips, 2002). The number of segments (Shin & Stulz, 1998) and Herfindahl index (Rajan, et al., 2000; Khanna & Tice, 2001; Maksimovic & Phillips, 2002) are used as variables representing the extent of diversification. Maksimovic and Phillips (2002) show that investment sensitivity increases with a firm's Herfindahl index<sup>17</sup>. Thus, in this research, the Herfindahl index is used as a variable to define the extent of diversification, which computes a firm's dispersion across the segment in which it operates by summing the squared shares of total firm sales for each segment.

To consider environmental factors which can affect investment decision, previous corporate finance studies typically contain control variables to focus on the targeted relationship in their estimations. Therefore, firm fixed effects are included to control for any heterogeneity across firms, calendar-year dummies, firm size, and a firm's specific character. Logarithm of total employees is used as a variable of firm size, segment sales in the previous period to avoid correlation with investment opportunities, and leverage in the previous period to control for the effect of external capital markets. Thus, the final model estimated in this study is described as follows:

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<sup>17</sup> As well as Herfindahl index, entropy measure of diversification can be also applied and Palepu (1985) used entropy measure in his research on profit performance of diversification strategy. However, due to the characteristics that various businesses are mixed in same segment, determining relatedness among businesses is difficult in the case of Japanese PRCs, thus, this study uses Herfindahl index. For the details of the diversification index, see Appendix 6.A.

$$\begin{aligned}
& \frac{\text{Capital expenditure}_{transportation,t}}{\text{Total assets}_{firm,t-1}} \\
&= \alpha_0 + \alpha_1 \cdot \frac{CF_{transportation,t}}{\text{Total assets}_{firm,t-1}} + \alpha_2 \cdot \frac{CF_{others,t}}{\text{Total assets}_{firm,t-1}} + \alpha_3 \cdot ROA_{transportation,t-1} \\
& \quad + \alpha_4 \cdot \text{Diversification index}_{firm,t-1} + \alpha_5 \cdot \text{Leverage}_{firm,t-1} \\
& \quad + \alpha_6 \cdot \text{Segment sales}_{transportation,t-1} + \alpha_7 \cdot \text{Total sales}_{firm,t-1} \\
& \quad + \text{Dummy}_{year} + \text{Dummy}_{firm} \tag{6.3}
\end{aligned}$$

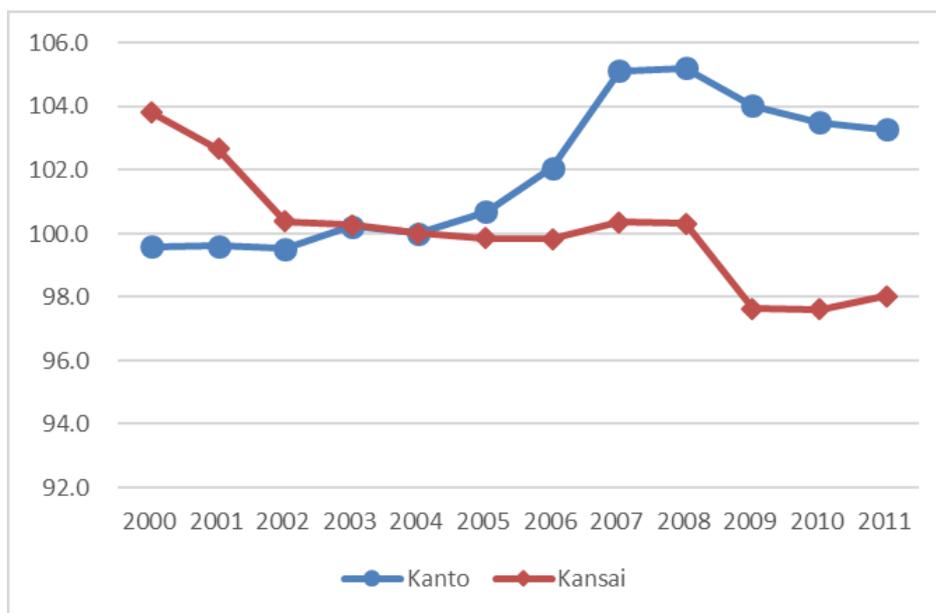
Table 6.1 presents the descriptive statistics of the variables used in the regressions.

*Table 6.1 Descriptive statistics*

Variable	Obs.	Mean	Std. Dev.	Min	Max
Investment sensitivity	215	0.0304	0.0176	0.0039	0.0927
Free cash flow of the transportation segment (million Yen)	215	-22841	55234	-237520	259485
Free cash flow of the other segments (million Yen)	215	-65174	60753	-309031	17072
Return on assets (ROA) of the transportation segment (%)	215	4.1256	1.4360	0.96	8.44
Herfindahl index	215	0.6950	0.1037	0.2450	0.8280
Long-term leverage	215	0.3522	0.0824	0.1560	0.5327
Segment sales in t-1 (million Yen)	215	357999	472550	35722	1955944
Total sales in t-1 (million Yen)	215	732026	608641	168582	2703563

## Estimation Results

To investigate investment decisions of the transportation segment by ICMs in order to confirm the robustness of the analysis, the baseline equation is estimated at first and model including the diversification index for the total sample is also estimated. Then, the sample is categorised into two groups by operation region, namely the Kanto region surrounding the Tokyo metropolitan area (TMA) and the Kansai regions including Osaka, Nagoya, and Fukuoka. Finally, the same models for both groups are estimated. Shoji (2001) suggests that the business strategies and the types of diversification strategies differ between Kanto and Kansai regions, as well as the trend of population along the railway line and demand of railway service.



*Figure 6.2 Change in the passenger of the Kanto region and the Kansai regions (2004 = 100, Year means of annual passenger)*

Source: Annual report on railway statistics, Japanese Ministry of Land, Infrastructure and Transport

Thus, it is expected that categorising the sample into two groups offers implications on relations among railway demand, diversification, and investment in the railway business. This is especially so considering the different levels of two regions: railway demand is gradually increasing in the Kanto region because of the pollution influx into the TMA, whereas demand is decreasing in the Kansai region (see Figure 6.2). The regression is estimated by using unbalanced panel data. All regressions contain firm-fixed effects and calendar-year dummies for each year, and the heteroscedasticity robust t-statistics are reported in parentheses. However, the coefficients of calendar-year dummies have been omitted because of space restrictions. Table 6.2 presents the estimates of the baseline investment equation and the model including the diversification index, which implies the extent of diversification.

Table 6.2 Variable estimation of the investment equation

	Capital expenditures in t/Total assets in t-1					
	Total	Kanto	Kansai	Total	Kanto	Kansai
Own cash flow ( $\alpha_1$ )	-0.6026*** (-8.43)	-0.7570*** (-9.99)	-0.4749*** (-4.04)	-0.5958*** (-8.29)	-0.7875*** (-13.21)	-0.4632*** (-4.17)
Other cash flow ( $\alpha_2$ )	0.1098** (4.29)	0.2738*** (3.86)	0.0950* (1.96)	0.1205*** (4.94)	0.0899** (3.22)	0.1294** (2.42)
Segment's ROA ( $\alpha_3$ )	0.0016** (2.67)	0.0004 (1.46)	0.0007 (0.73)	0.0015** (2.60)	0.0001 (0.22)	-0.0003 (-0.25)
Diversification Index ( $\alpha_4$ )				0.0370* (1.82)	-0.0512 (-1.09)	0.0862** (2.36)
Leverage in t-1 ( $\alpha_5$ )	-0.0024 (-0.16)	-0.0292 (-1.74)	-0.0025 (-0.11)	-0.0109 (-0.86)	-0.0310 (-1.81)	-0.0238 (-1.06)
Segment sales in t-1 ( $\alpha_6$ )	-0.0126 (-0.39)	0.0713 (0.9)	0.0320 (0.71)	-0.0058 (-0.21)	0.0990 (1.54)	0.0494 (1.59)
Firm size (log of total sales) ( $\alpha_7$ )	-0.0027 (-0.57)	0.0069 (1.34)	-0.0048 (-0.51)	-0.0042 (-0.86)	0.0052 (0.79)	-0.0148 (-1.37)
Constant ( $\alpha_0$ )	0.0468 (0.72)	-0.0744 (-1.12)	0.0658 (0.55)	0.0462 (0.71)	-0.0198 (-0.19)	0.1543 (1.18)
Observations (Groups)	215 (17)	104 (8)	111 (9)	215 (17)	104 (8)	111 (9)
R <sup>2</sup>	0.7826	0.9074	0.6901	0.7895	0.9129	0.7269

\* Significant at the 10% level, \*\* Significant at the 5% level, \*\*\* Significant at the 1% level

In the estimation of the total sample, the coefficients of cash flow are statistically significant in all models and the absolute value of the coefficients of a transportation segment's cash flow is larger than that of cash flow of other segments. This finding corresponds with those of other previous research that the investment decision depends more on its own segment's cash flow; however, the sign of the coefficient of own cash flow is negative. This implies that an increase in the cash flow of the transportation segment is not always connected with additional investment in segment.

On the contrary, segment ROA, which is a proxy for investment opportunities, is significant, but the coefficients are small compared with those of other variables and this is a remarkable difference to that for non-regulated firms. As discussed above, investment opportunities affect the decisions of the ICMs and are positively related to a segment's investment. This finding implies that investment in the transportation segment is unlikely to depend on the profit decision completely, in contrast to a non-

regulated firm's segments. In the model including diversification, the coefficient of the diversification index is positive and statistically significant. This finding means that deploying a diversification strategy positively influences transportation investment.

Considering the demand side, the firms operating in the Kanto region, where passenger demand tends to grow, are more influenced by their own cash flow than those of firms operating in the Kansai regions. In the Kansai region where decreased passenger demand is likely, the coefficient of the diversification index is positive and significant and its effect is twice as large as that in the Kanto region. Thus, expanding the extent of diversification strategies can positively affect investment in the transportation segment if the number of railway passengers is likely to decrease.

## **Discussion**

Estimation results of the investment equation of PRCs indicate that the investment policy of these companies is different from that of firms operating in non-regulated or manufacturing industries. Based on the coefficients of segment's own cash flow, other segments' cash flow, and segment ROA, ICMs are not efficient on investment in transportation segment, because it is more sensitive to cash flow of its own segment and other segments than investment opportunities, represented by segment ROA. The most remarkable finding of this study is that the diversified strategies of PRCs may not ensure additional financing to the transportation business. The railway business, similar to other diversified businesses of major PRCs, is profitable, allowing it to generate the cash necessary for investment. If a firm only operates in the railway business, all generated cash is reinvested in railways. However, in a diversified firm, the cash flow generated by a transportation segment's activities may be invested in another segment. Hence, while it may be anticipated to gain the benefit by improving efficiency and focusing on core businesses by allowing private operations and diversifying business portfolio, this may become distorted as private operators choose expansion to diversification, not concerning profitability and investment opportunities (Thompson, 1999).

Given that the railway business is the core business of a firm and that diversification

is motivated to support it, it is supposed that the railway segment is prioritised above other segments when deciding on investment. Indeed, it is confirmed that the extent of diversification strategies positively influences investment in a transportation segment and the cash generated from other segments also flows into transportation. If the diversified businesses have ability to create enough cash, generated cash may contribute to investment in transportation segment, including railway business. However, it is necessary to focus on the negative impact of the cash flow of the transportation segment, whereby cash flows out of the transportation segment into other diversified segments. In addition, the impact of the cash outflow from the transportation segment is about three times larger than that of the cash inflow from other segments in all models. This finding indicates that the effect of the cash inflow from other segments can be offset by the cash outflow from the transportation segment. Further, it can be considered that the railway business has thus far been a cash generator in the firm based on the stable demand factor, as discussed above. It is observed that investment in non-core segments depends on the cash of core business in the case of oil companies (Lamont, 1997). Thompson (1999) also points out that a firm whose core businesses are stable cash generators, but market-matured and regulated by price regulations, has few real opportunities to grow its core businesses and tends to invest other businesses that are expected to achieve growth in the case of newly privatised UK utilities.

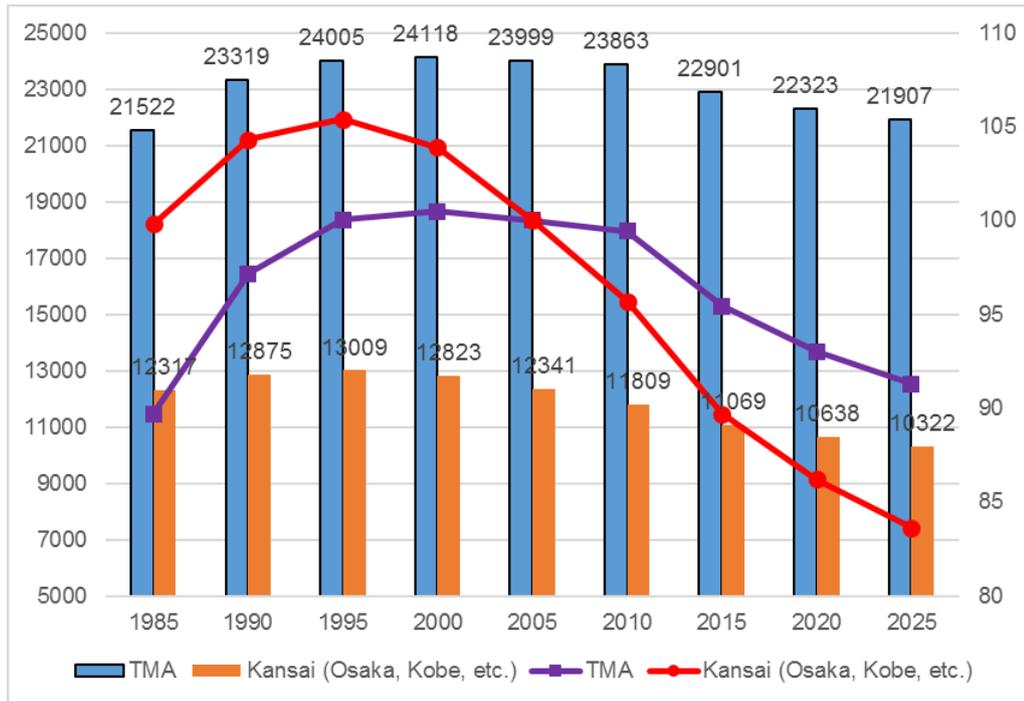


*Figure 6.3 Change of ROA of transportation segment and diversified segments of major PRCs and JR companies in Japan (Year means)*

However, it is needed to beware of understanding that transportation investment is not performed or is negative. Capital expenditures are used not only to acquire physical assets, but also to upgrade current assets. As shown in the models of the total sample, the coefficient of the ROA of the transportation segment, which is a proxy of investment opportunities, is significant and positive, but its impact is slight. This finding means that investment opportunities, which emphasise profitability and affect investment decisions, are not always critical to decision of investment in the transportation segment compared with other factors. The slight impact of ROA may come from the regulations placed on the railway business. Government-regulated PRCs must thus control service quality and maintain safety by regulation or law related to operation and safety. They also have a responsibility to maintain a certain level of service because their core business is the railway business and the firm's characteristics are defined by operation of railway business. In other words, a firm is obliged to undertake the required level of investment following the regulation. However, profitability and growth are important factors for private firms when deciding on investment. In terms of new investment, the headquarters may be reluctant to allocate capital to acquire new assets or enhance transportation facilities based on future demand and predicted profitability. As presented in Figure 6.3, the profitability of transportation segments presented by ROA have been greater than that of other diversified segments. However, the gap between two types of segments has been smaller, and ROA of diversified segments is almost the same as that of transportation segment in 2012. It implies that investment in transportation segment is not attractive and the best alternative to use internal capital in diversified PRCs.

Consequently, a firm may only invest at the required level and it becomes less inclined to invest in the development of new routes and in large-scale changes not obligated by the regulations and cash is allocated to expand diversification when the railway business is making a profit and generating cash for investment. The interview is performed to the managers of three major PRCs in the Kansai region and it is confirmed that most PRCs tend to rely on funds from Development Bank of Japan (e.g. low interest loans) or financial support programmes which are provided if PRCs

operate jointly with the public sector (e.g. the establishment of the quasi-public sector) when they plan to construct or improve infrastructure at the large scale. Of course, it seems that Japanese PRCs may not utilise internal capital because of the existence of such support schemes, although the support is minimal compared with other countries. However, given the low promise of the future growth of railway business, support schemes offered by public sector, although not large, may serve as insurance to guarantee a certain level of quality in the provision of railway services. Moreover, the support schemes allow transportation segment of PRCs to acquire external funds easily compared with diversified segment. PRCs generally diversify into non-regulated industries, as discussed above, and this indicates that acquiring external capital for diversified business is more difficult than railway business because the project may be strictly evaluated in terms of profitability and the external agency would not have consideration for low interest based on the market principle. Lamont (1997) proves that relatively better external financial condition of oil business allows the firm to invest in non-oil segments in the case of U.S. oil companies. Therefore, negative relationship between investment sensitivity and cash flow of transportation segment is caused by aggravated investment opportunities of transportation segment, which is represented by ROA, and external financial constraint of each segment. As a result, it is hard to expect to allocate internal capital for railway business more than other segments.



(Actual value is used until 2010, and estimated value is used from 2015)

Figure 6.4 Trend of productive age population (2005 = 100)

Source: (Actual value) National census, Japanese Statistics Bureau and Statistics Centre (2010)

(Estimated value) Regional Future Estimated Population in Japan, National Institute of Population and Social Security Research (2013)

Moreover, the different impacts of the transportation segment's cash flow and the extent of diversification between two regions are remarkable. First, in terms of productive age population, which generates stable demand for railway companies by commuting, the population in the Kansai region is shrinking at a greater rate than that in the Kanto region (see Figure 6.4). Second, in the Kansai region, three companies (JR, Hankyu, and Hanshin) are competing on the same route from Kobe to Osaka, while there are hardly any competing routes in the Kanto region. The companies in the Kanto region where the number of passengers has increased are likely to respond more sensitively to the transportation segment's negative cash flow than the companies in the Kansai region, as shown in Figure 6.2. The coefficient of diversification index of the companies in the Kanto region is also negative, but is not statistically significant, while that of the companies in the Kansai area is positive and significant. As mentioned above, although the population is decreasing in both regions, the Kanto region shows a smaller drop than the Kansai region. This indicates

that potential demand for the railway business is more stable in the Kanto region. Considering that revenue from the railway business still accounts for an important part of the revenue of railway companies and that diversified segments, such as distribution including retail and restaurant, recognise passengers of railway service as their potential customer as Shoji (2001) discussed, this suggests that the cash flow of railway segment is an important capital resource for their diversification. Because companies that have sufficient railway demand tend to have an interest in higher profitability businesses based on the assurance for future demand, rather than securing further demand by enhancing railway services, they restrict new investment in the transportation segment.

The existence of competitors on the same route also influences the relationship between diversification and investment in the railway business. This competitive situation may drive railway companies to build and integrate strategies in order to strengthen the railway business, which is their core business. Although reinvestment in the railway business by its own cash flows may decrease because of the use of diversification strategies, cash from the transportation segment may be deployed to support diversified segments, which supports the railway business and makes it attractive to passengers. This view is supported by Shoji (2001), who suggests that the proportion of dominated and related types according to Rumelt's categorisation in the Kansai region is higher than that in the Kanto region. Therefore, the expectation of future demand and existence of competitors may act importantly in capital allocation among PRCs. In spite of tendency which capital is allocated to diversified segments, restricting the diversification of private operators is not a desirable choice. The aggravated environment surrounding passenger railway services, such as competition with individual transportation and decrease in population size, becomes a burden to railway operators; thus they need strategies to guarantee their financial sustainability, and diversification may play a role in this regard. Diversification may be incentive for operators because it opens up the possibility of creating various income sources and seeking further growth opportunities. This indicates that the firm may overcome the limited profitability of railway services owing to fare regulation by

diversifying. Therefore, designing financial support programmes for improving infrastructure and formulating a regulatory scheme to monitor the weak governance systems of private operators, which is related to wasteful investment (Mueller, 1972; Jensen, 1986; Markides, 1995; Thompson, 1999), is needed to minimise the influence on railways.

## **Summary**

In this chapter, how diversification influences investment in the railway business is examined focusing on the capital allocation performed by the firm's headquarters in ICMs and empirical model is estimated using data on Japanese PRCs. The railway business is usually considered to take priority when the firms establish their investment policies because diversification strategies of PRCs result from the effort taken to support railways. Thus, it is demonstrated that diversification has a positive impact on investment in the railway business, but that the diversification strategies used are questionable in terms of supporting railway business.

One practical implication of this research is that it is difficult for diversified PRCs to utilise internal capital for investment to improve and expand railways. This results from the external capital condition of railway business relatively flexible comparing to diversified other segments, and being aggravated profitability. As confirmed in the interview with the managers of three major PRCs in the Kansai region, PRCs is still likely to rely on the financial schemes by public sector to construct or improve infrastructure in large scale. Further, diversifying properly can therefore contribute to creating abundant capital resources inside a firm. However, the allocation decision is made by the headquarters, which consider future profitability and growth first. Although private operators have the flexibility and freedom to design service and business strategies, owing to the expected decreasing railway demand, enhancing railway infrastructure may be overwhelmed by other, more profitable segments. It is also confirmed that the internal capital of PRCs is mainly used to diversify businesses, rather than railway business. As well as existence of competitors in railway business, differences in the operating region of PRCs and form of diversification strategies are

influential factors to determine allocation of internal capital. This result infers that it is difficult to expect that generated cash inside a firm is used for improvement of railway business. Even though internal capital generated by diversification is not likely to be utilise for railway business, restricting diversification is not appropriate considering aggravated environment of railway services. Rather than expecting use of internal capital for railway, it may be better that financial schemes or support programmes are set by public sector to support or encourage constuction of railway infrastructure continually. Regulation and monitoring to manage negative influence of diversification are also needed.

## Appendix 6.A Measure of Diversification<sup>18</sup>

Although Rumelt (1974) proposed categorical measurement of diversification which captures well the subtleties of a firm's diversification strategies, it is subjective in terms of determining relatedness and verticality of business, and very time-consuming (Palepu, 1985). In case of PRCs in Japan, because different types of businesses are included in a segment in group-level, use of Rumelt's classification may cause excessive intervention of subjectivity of the researcher to define relatedness. Therefore, among the industrial organisation researchers prefer the index approach to the categorical approach (Montgomery, 1982). Although the diversification indices, such as Herfindahl index and entropy index, have a disadvantage which do not distinguish between related and unrelated diversification, they are easy to calculate, objective, and replicable, comparing to the categorical approach (Palepu, 1985). These diversification indices describe industrial concentration of diversified firm, thus are computed using the shares of each product or segment.

Of the diversification indice, Herfindahl index is the most widely used measurement due to its convenience of computation and understanding<sup>19</sup>. Most measures of corporate diversification takes the form:

$$I = \sum_{i=1}^n P_i \omega_i \quad (6.A.1)$$

where  $P_i$  is the share of the  $i$ th segment or industry and  $\omega_i$  is an assigned weight. Generally, weight is assigned to the share of each segment or industry of the firm while the share of all other segments or industries within the firm receive a weight of zero. Thus, Herfindahl's contribution can be described as follows:

$$H = \sum_{i=1}^n P_i P_i \quad (6.A.2)$$

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<sup>18</sup> This section is based on Jacquemin and Berry (1979) and Palepu (1985).

<sup>19</sup> For details, see Jacquemin and Berry (1979).

However, the degree of diversification of the firm is determined by the level of product or business aggregation, because concentration will be lower the more aggregated the industry or product definitions on which the measure is based. Thus, generally, Herfindahl index of diversification is defined as follows to make it increase with increasing diversification:

$$H = \left( 1 - \sum_{i=1}^n P_i^2 \right) \quad (6. A. 3)$$

<sup>20</sup>As well as Herfindahl index, entropy measure of diversification can be also applied and Palepu (1985) used entropy measure in his research on profit performance of diversification strategy. Entropy measure is based on the number of product segments, the distribution of the firm's total sales across the product segments, the degree of relatedness among the various product segments (Palepu (1985, p.244)). Because entropy measure is able to consider degree of relatedness, it overcomes the limitation of Herfindahl index. Thus, it can decompose a firm's total diversity into two additive components: 1) an unrelated component that measures the extent to which a firm's output is distributed in products across unrelated industry groups, and 2) a related component that measures the distribution of the output among related products within the industry groups (Palepu (1985, p.244)).

If a firm operates in  $N$  industry segments, the entropy measure of total diversification DT is defined as follows:

$$DT = \sum_{i=1}^N P_i \ln(1/P_i) \quad (6. A. 4)$$

where,  $P_i$  is the share of the  $i$ th segment in the total sales of the firm. In equation (6.A.4), the weight for each segment is the logarithm of the inverse of its share, thus, this is a weighted average of shares of the segments.

As mentioned above, the entropy measure is distinguished from other indice because it takes into account the degree of relatedness among the various segments

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<sup>20</sup> For details, see Palepu (1985).

of the firm. If it is assumed that a set of related segments is defined as an industry group, then, the segments within an industry group are expected to be more related than other segments which are classified into other industry groups. In addition, it can be assumed that there are  $N$  industry segments of the firm and these segments can be aggregated into  $M$  industry groups ( $N \geq M$ ). Thus,  $DR_j$ , which is the related diversification resulting from operating in several segments within an industry group  $j$ , can be defined as follows:

$$DR_j = \sum_{i \in j} P_i^j \ln(1/P_i^j) \quad (6.A.5)$$

where,  $P_i^j$  is the share of the segment  $i$  of group  $j$  in the total sales of the group. However, the firm is assumed to operate in several industry groups, total related diversification  $DR$  is the sum of  $DR_j$ ,  $j = 1, \dots, M$ .

$$DR = \sum_{j=1}^M DR_j P^j \quad (6.A.6)$$

where,  $P^j$  is the share of the  $j$ th group sales in the total sales of the firm.

On the other hand,  $DU$  represents the unrelated diversification and originate from operating across several industry groups.  $DU$  is defined as follows:

$$DU = \sum_{j=1}^M P^j \ln(1/P^j) \quad (6.A.7)$$

Therefore, under the above definitions, the total diversification is described as the sum of the related and unrelated components. Note that  $P_i^j = P_i/P^j$  and  $P^j = \sum_{i \in j} P_i^j$ .

$$\begin{aligned} DR + DU &= \sum_{j=1}^M DR_j P^j + \sum_{j=1}^M P^j \ln(1/P^j) = \sum_{j=1}^M P^j \left[ \sum_{i \in j} P_i^j \ln(1/P_i^j) + \ln(1/P^j) \right] \\ &= \sum_{j=1}^M P^j \left[ \sum_{i \in j} (P_i/P^j) \ln(P^j/P_i) + \ln(1/P^j) \right] \\ &= \sum_{j=1}^M \left[ \sum_{i \in j} P_i \ln(1/P_i) + \ln(P^j) + \ln(1/P^j) \right] \end{aligned}$$

$$= \sum_{j=1}^M \sum_{i \in j} P_i \ln(1/P_i) = DT \quad (6.A.8)$$

## 7. Summary and Conclusion

### Summary

The aims of this study were to examine the effect of diversification strategies of Japanese PRCs quantitatively and to provide implication for operators, who pursue innovative business model for future growth and profitability, and for authorities who struggle to improve efficiency of operation of public transportation.

Chapter 2 gives an overview of diversification strategies by reviewing previous literature in strategic management and industrial organisation. With motivation and type of diversification strategies, topics of relationship diversification strategies and the firm's performance are scrutinised to provide implications of behaviour of Japanese PRCs. Considering strategic environment of Japanese PRC, this study also focuses on the diversification strategies of the firm whose main business area is service industry, and of the public utility firms.

Chapter 3 describes features of urban transportation system in Japan and gives overview of diversification strategies of Japanese PRCs. The most distinctive features of Japanese PRCs are private operation independent of the government and diversification strategies deployed widely. While transportation segment including railway business is still profitable, the proportion of diversified segments in total operating profit has increased and its business area has been also expanded.

Chapter 4 gives an outline of production function and stochastic frontier analysis measuring technical efficiency. In chapter 5, the relationship between diversification strategies and the firm's technical efficiency is examined by estimating output oriented production function using stochastic frontier analysis. With estimation of production function, the model clarifying the factors influencing inefficiency (inefficiency model) is also estimated. In estimation, the sample consisting of data of 34 diversified PRCs from 2000 to 2012 is used. Diversification strategy influences the firm's technical efficiency which represents the firm's capabilities transferring resources and assets to core competencies which assure the firm competitive advantages, while excessive diversification strategies have negative effect on efficiency.

In chapter 6, the effect of diversification on investment decision of Japanese PRCs is investigated. The role and efficiency of ICMs which are the channel allocating funds for each segment are discussed, and life-cycle theory and free cash-flow theory are applied to clarify the use of cash flow inside the firm.

## **Findings and Implications**

This study consists of two analyses: the efficiency of diversification strategies of PRCs and the effect of diversification strategies on investment of railway business. This study contributes to investigating the influence of diversification from the two aspects: 1) examining influence on the efficiency of entire firm which indicates the capability sharing resources and utilising relatedness, 2) exploring possibility of use of internal capital for investment of railway business in diversified environment. Based on the discussions earlier, this study can provide some insights for private operation and design of innovative future business model for railway business.

First of all, the results from analysis of technical efficiency and the factors influencing inefficiency show that diversification strategies, which just pursue expansion of business, cannot contribute to improvement of the firm's efficiency. Although there are some previous studies estimating the regression of diversification strategies on railway demand quantitatively and comparing the type of diversification strategies and profitability of PRCs simply, the efficiency of PRCs as performance has not been considered so far. In diversified firms, assets and resources can be transferred among divisions, however, the use of them entails costs. In addition, the inefficiency model provides an evidence that increase of the proportion of real estate and distribution business improves the firm's efficiency. As mentioned above, technical efficiency is related to capability transforming and sharing resources. As well as profitability, retaining competitive advantage and exploring core competencies through appropriate use of strategy are an important factor to guarantee the firm's sustainability and to open the possibility for future growth. Through the estimated model, this study proposes that diversified PRCs should expand businesses using physical assets highly regarded in railway business and focusing on the related

business.

Although diversification strategies of major PRCs, which expands into new business area and outside operating region, have raised the question about their efficiency, it has not been enough explored so far. As including interaction term of the extent of diversification and dummy variable for major PRC, this study tries to discuss effectiveness of their diversification strategies which seek expansion of business areas numerically. Some major PRCs tend to try emerge from the range of transportation companies, thereby entering into businesses unfamiliar with traditional diversification and deploying businesses outside the area operating railway. It seems like some kind of innovation to break the limitation as transportation companies, however, it causes ineffectiveness in governance and transaction costs resulting from expanding of organisation and sharing idea and resource between heterogeneous divisions.

In view of investment, this study clarifies that it is hard to expect utilising internal capital for railway investment. This implies that diversification may not play a role as supporter of railway business by supplying cash. However, diversification strategies are still valid for PRCs because it is expected that diversification contributes to the firm's future growth and mitigation of income fluctuation due to decreasing demand of railway business. Considering negative effect of excessive expansion as mentioned above, the strategy, which utilises internal capital for the diversified businesses that are close to railways and are growing, will be effective to sustainability of PRCs.

In addition, to prevent diversification strategies of PRCs from being biased in growth and profitability excessively, the role of public authorities is still emphasised. Especially, to prevent value-decreasing diversification and negative influence on railway business, government should not loosen to monitor the firm's behaviour which threatens sustainability and public interest of railway business. Although PRCs make their own strategies and act based on the market principal, they should be continued to provide stable public transport service. Therefore, as a surveillant, government should keep watch on the firm's behaviour and retain the accounting report system

for transparent operation of railways by continuing railway accounting rule which is referred above. Moreover, government should provide financial support programmes and schemes for improvement and construction railway infrastructure which need a huge cost. Indeed, minimal regulation and support are needed to retain public transport and satisfy public interest considering their speciality as public transport operator, although PRCs exist as private firms.

As a result, for PRCs and operators, this study proposes that it is necessary to exploit assets of railway business, such as terminals and main stations, know-how, and passengers, and diversify businesses in which their core competencies can be utilised effectively, thereby improving efficiency of the firm and establishing future-oriented management system which considers the firm's sustainability. For the authorities which consider introducing diversification to railway operators, they should not forget that diversification is hardly to be solution for offering capital to railway business. As discussed above, in diversified railway operators, internal capital is likely to be used for diversified business, given the condition which the firm allocates capital by its own decision. Thus, if the authorities expect diversified operators to utilise internal capital for railway investment, the regulation which obligates the firm to use certain proportion of internal capital generated by diversification for railway investment may be needed. However, rather than obligation, it is desirable that the authorities back the operators up by supporting scheme encourage construction and improvement of infrastructure. In addition, they should recognise diversification strategies as the tool aiming enhancement of profitability of the operators, thereby reducing subsidies for operating deficit.

### **Limitations and Future Research**

Although the results and findings from this study provide implications of diversification strategies of railway operators, there are some limitations of this study which should be recognised for future research.

First of all, in the analysis of the efficiency of diversification strategies of PRCs, although production distance function is estimated to obtain technical efficiency and

to investigate factors which affect inefficiency by stochastic frontier, estimating cost frontier is also considered to describe the production technology of PRCs, thereby predicting cost efficiency. To estimate cost frontier, it is needed to assume that firms minimise costs, as well as getting price data of inputs. According to Smith (2006), some previous literature (e.g. Caves, Christensen and Swanson (1981)) points out the inappropriateness of cost function estimation of railway sector because managers do not have authorities to adjust the level of capital input optimally. In fact, PRCs determine the amount of expenditures for capital input as independent private enterprises and this is recorded in the firm's financial statement as capital expenditures. In addition, it may be desirable to assume that PRCs seek to maximise profit even for the railway business, although it is regulated and is forced to consider public interest. Therefore, further research is necessary to compare technical efficiencies derived from production frontier and cost frontier in order to provide in-depth implications considering both effective use of inputs and cost impact of different businesses.

Although the factors, which are related to diversification strategy, such as the extent of diversification strategy and the ratio of the sales of physical related businesses (e.g. real estate, retail), are mainly considered in inefficiency model, other factors like regulation on railway business, governance, organisation structure of the firm and source of capital resource (leverage) may influence technical efficiency which represents the capability sharing resources in this research. In fact, external capital condition, such as financial support scheme of railway business, is referred as the factor influencing relationship between investment sensitivity and cash flow in chapter 6. This study focuses on the diversification strategies and the scale of the firm, owing to the limitation of inefficiency model which is hard to converge if too many explanatory variables are included, and to investigate the effect of diversification strategies intensively. Other forms of quantitative models (e.g. logistics regression) can be applied to include various factors and to control other factors which are possible to influence on the firm's technical efficiency. This proposed work may examine the effect of diversification strategies on the firm's technical efficiency clearly.

Some questions also remain with respect to whether diversification strategies influence a firm's profitability or value by affecting technical efficiency. Although this study considers improving technical efficiency as a critical performance of a firm, accomplishing high profitability and value in the market are still important goal to be reckoned with for a firm. It is not certain whether the effect on profitability and the firm's value result from the effective strategy sharing strategic assets which can form competitive advantages of the firm or economies of scope obtained by simply operating multiple businesses, while diversification strategies influence technical efficiency positively. As discussed above, the distinct benefit of diversification, like competitive advantage, is driven not by the simple utilization of resources, but by the intangible and inimitable resources of a firm. Thus, to ensure the effect of diversification strategies, it is important to investigate the effect of diversification strategy on a firm's efficiency, separating from economies of scope.

In terms of effect of diversification strategies on investment of railway business, this study cannot investigate whether diversification is deployed desirably for future growth and financial sustainability. This study confirms that transfer of cash flow from transportation segment to diversified businesses occur in PRCs, because core business, which is railway business, is matured and it is hard to expect high future growth based on life-cycle theory and free cash-flow theory. In addition, it is referred that cash may be used to deploy diversified businesses which can exploit synergy effect with railway business. Thus, it would be instructive to investigate whether the cash generated from railway business is transferred to the segments which can contribute to the future growth of the firm or support railway business.

As Jensen (1986) discussed, weak governance system can trigger investment distortion which the manager uses capital for the project that is hard to expect high investment opportunity and future growth. The way of capital allocation may also be different between subsidiaries in conglomerate and business division inside the firm. Thus, further research of the extent of the governance systems of PRCs and the influence of organisation system of PRCs will give valuable implications to investigate the effect of diversification strategies on investment of railway business. In addition,

studying the forms of external capital that affect the investment decisions of the railway business such as loans, subsidies, and stocks, and examining the support programmes to mitigate the tax rate or interest are also recommended to clarify the relationship between diversification and investment further, when focusing on internal capital market inside a firm. These questions are left to future research.

## Bibliography

- Ahn, S., Denis, D. J. & Denis, D. K., 2006. Leverage and investment in diversified firms. *Journal of Financial Economics*, 79(2), pp. 317-337.
- Aigner, D. J., Lovell, C. A. K. & Schmidt, P., 1977. Formulation and estimation of stochastic frontier production function models. *Journal of Econometrics*, 6(1), pp. 21-37.
- Almeida, H., Campello, M. & Weisbach, M. S., 2004. The cash flow sensitivity of cash. *The Journal of Finance*, 59(4), pp. 1777-1804.
- Amihud, Y. & Lev, B., 1981. Risk reduction as a managerial motive for conglomerate mergers. *The Bell Journal of Economics*, 12(2), pp. 605-617.
- Amit, R. & Schoemaker, P. J. H., 1993. Strategic assets and organizational rent. *Strategic Management Journal*, 14(1), pp. 33-46.
- Ansoff, J. I., 1957. Strategies for diversification. *Harvard Business Review*, Sep-Oct, 35(5), pp. 113-124.
- Baek, H. Y., 2004. Corporate diversification and performance evidence on production efficiency. *Journal of Multinational Financial Management*, 14(2), pp. 135-152.
- Baker, G., 1986. *Compensation and Hierarchies*. s.l.:Harvard Business School.
- Battese, G. E. & Coelli, T. J., 1988. Prediction of firm-level technical efficiencies with a generalized frontier production function and panel data. *Journal of Econometrics*, 38(3), pp. 387-399.
- Battese, G. E. & Coelli, T. J., 1992. Frontier production functions, technical efficiency and panel data: With application to paddy farmers in India. *The Journal of Productivity Analysis*, 3(1/2), pp. 153-169.
- Battese, G. E. & Coelli, T. J., 1993. *A stochastic frontier production function incorporating a model for technical inefficiency effects*. Working Papers in Econometrics and Applied Statistics No. 69: Department of Econometrics, University of New England, Armidale.
- Battese, G. E. & Coelli, T. J., 1995. A model for technical inefficiency effects in a stochastic frontier production function for panel data. *Empirical Economics*, 20(2), pp. 325-332.
- Beckers, D. E. & Hammond, C. J., 1987. A tractable likelihood function for the normal-gamma stochastic frontier model. *Economis Letters*, 24(1), pp. 33-38.
- Berger, P. G. & Ofek, E., 1995. Diversification's effect on firm value. *Journal of Financial Economics*, 37(1), pp. 39-65.
- Berthon, P., Pitt, L., Constantine, S. K. & Paul, J., 1999. Virtual services go international: International services in the marketplace. *Journal of International Marketing*, 7(3), pp. 84-105.
- Bettis, R. A., 1981. Performance differences in related and unrelated diversified firms. *Strategic Management Journal*, 2(4), pp. 379-393.
- Billett, M. T. & Mauer, D. C., 2003. Cross-subsidies, external financing, constraints, and the contribution of the internal capital market to firm value. *The Review of Financial Studies*, 16(4), pp. 1167-1201.
- Capar, N. & Kotabe, M., 2003. The relationship between international diversification

- and performance in service firms. *Journal of International Business Studies*, Volume 34, pp. 345-355.
- Caves, D. W., Christensen, L. R. & Swanson, J. A., 1981. Productivity growth, scale economies, and capacity utilization in U.S. railroads, 1955-74. *The American Economic Review*, 71(5), pp. 994-1002.
- Channon, D. F., 1979. *The Service Industries: Strategy, Structure and Financial Performance*. 1 ed. London: Macmillan.
- Chatterjee, S. & Wernerfelt, B., 1991. The link between resources and type of diversification: Theory and evidence. *Strategic Management Journal*, 12(1), pp. 33-48.
- Chen, C. M., Delmas, M. A. & Lieberman, M. B., 2015. Production frontier methodologies and efficiency as a performance measure in strategic management research. *Strategic Management Journal*, 36(1), pp. 19-36.
- Chou, E. S. W., 2010. Can socialism in internal capital markets occur in the absence of managerial rent seeking?. *Applied Economics*, 42(1), pp. 107-120.
- Coelli, T., 1995. Estimators and hypothesis tests for a stochastic frontier function: A Monte Carlo analysis. *The Journal of Productivity Analysis*, 6(3), pp. 247-268.
- Coelli, T. J. & Perelman, S., 2000. Technical efficiency of European railways: A distance function approach. *Applied Economics*, 32(15), pp. 1967-1976.
- Coelli, T. J., Rao, D. S. P., O'Donnell, C. J. & Battese, G. E., 2005. *An Introduction to Efficiency and Productivity Analysis*. 2nd ed. New York: Springer.
- Cornwell, C., Schmidt, P. & Sickles, R. C., 1990. Production frontiers with cross-sectional and time-series variation in efficiency levels. *Journal of Econometrics*, 46(1-2), pp. 185-200.
- Cuesta, R. A., 2000. A production model with firm-specific temporal variation in technical inefficiency: With application to Spanish dairy farms. *Journal of Productivity Analysis*, 13(2), pp. 139-158.
- D'Agostino, R. B. & Pearson, E. S., 1973. Tests for departure from normality. Empirical results for the distributions of  $b_2$  and  $\sqrt{b_1}$ . *Biometrika*, 60(3), pp. 613-622.
- Delmas, M. & Tokat, Y., 2005. Deregulation, governance structures, and efficiency: the U.S. electric utility sector. *Strategic Management Journal*, 26(5), pp. 441-460.
- Duchin, R., 2010. Cash holdings and corporate diversification. *The Journal of Finance*, 65(3), pp. 955-992.
- Dutta, S., Narasimhan, O. & Rajiv, S., 2005. Conceptualizing and measuring capabilities: Methodology and empirical application. *Strategic Management Journal*, 26(3), pp. 277-285.
- Färe, R. S. & Primont, D., 1995. *Multi-Output Production and Duality: Theory and Applications*. Boston: Kluwer Academic Publishers.
- Faulkender, M., Flannery, M. J., Hankins, K. W. & Smith, J. M., 2012. Cash flows and leverage adjustments. *Journal of Financial Economics*, 103(3), pp. 632-646.
- Gassenheimer, J. B. & Keep, W. W., 1998. Generalizing diversification theory across economic sectors: Theoretical and empirical considerations. *Journal of Marketing Theory and Practice*, 6(1), pp. 38-47.

- Geringer, J. M., Tallman, S. & Olsen, D. M., 2000. Product and international diversification among Japanese multinational firms. *Strategic Management Journal*, 21(1), pp. 51-80.
- Goddard, J., Mckillop, D. & Wilson, J. O. S., 2008. The diversification and financial performance of US credit unions. *Journal of Banking & Finance*, 32(9), pp. 1836-1849.
- Grabowski, H. G. & Mueller, D. C., 1975. Life-cycle effects on corporate returns on retentions. *The Review of Economics and Statistics*, 57(4), pp. 400-409.
- Greene, W. H., 1980. Maximum likelihood estimation of econometric frontier functions. *Journal of Econometrics*, 13(1), pp. 27-56.
- Greene, W. H., 1980. On the estimation of a flexible frontier production model. *Journal of Econometrics*, 13(1), pp. 101-115.
- Hensher, D. A. & Stanley, J., 2008. Transacting under a performance-based contract: The role of negotiation and competitive tendering. *Transportation Research Part A*, Volume 42, pp. 1143-1151.
- Hill, C. W. L., Hitt, M. A. & Hoskisson, R. E., 1992. Cooperative versus competitive structures in related and unrelated diversified firms. *Organization Science*, 3(4), pp. 501-521.
- Hovakiman, G., 2011. Financial constraints and investment efficiency: Internal capital allocation across the business cycle. *Journal of Financial Intermediation*, 20(2), pp. 264-283.
- Huang, C. J. & Liu, J. T., 1994. Estimation of a non-neutral stochastic frontier production function. *Journal of Productivity Analysis*, 5(2), pp. 171-180.
- Jacquemin, A. & Berry, C. H., 1979. Entropy measure of diversification and corporate growth. *The Journal of Industrial Economics*, 27(4), pp. 359-369.
- Jandik, T. & Makhija, A. K., 2005. Can diversification create value? Evidence from the electric utility industry. *Financial Management*, 34(1), pp. 61-93.
- Jensen, M., 1986. Agency costs of free cash flows, corporate finance and takeovers. *American Economic Review*, Volume 76, pp. 323-329.
- Jondrow, J., Lovell, C. A. K., Materov, I. S. & Schmidt, P., 1982. On the estimation of technical inefficiency in the stochastic frontier production function model. *Journal of Econometrics*, 19(2-3), pp. 233-238.
- Joshi, M. P., Kashlak, R. J. & Sherman, H. D., 1998. How alliances are reshaping telecommunications. *Long Range Planning*, 31(4), pp. 542-548.
- Kamata, H. & Yamauchi, H., 2010. An analysis of the diversification strategies of railway companies in Japan (Tetsudo kaisha no takakuka sennryakuni kansuru bunseki). *Journal of Transportation (Koutsugaku Kenkyu)*, Volume 54, pp. 95-104 (in Japanese).
- Kashlak, R. J. & Joshi, M. P., 1994. Core business regulation and dual diversification patterns in the telecommunications industry. *Strategic Management Journal*, 15(8), pp. 603-611.
- Kennedy, J. & Smith, A. S. J., 2004. Assessing the efficient cost of sustaining Britain's rail network: Perspectives based on zonal comparisons. *Journal of Transport Economics and Policy*, 38(2), pp. 157-190.
- Khanna, N. & Tice, S., 2001. The Bright Side of Internal Capital Markets. *The Journal of Finance*, 56(4), pp. 1489-1528.

- Killeen, J. B., 1999. *Business diversification and integration strategy of urban private railways in Japan: An economic analysis of strategy, market performance and policy implications*. Doctor of Commerce Thesis, Graduate School of Business Administration, Kobe University.
- Kodde, D. A. & Palm, F. C., 1986. Wald criteria for jointly testing equality and inequality restrictions. *Econometrica*, 54(5), pp. 1243-1248.
- Kumbhakar, S. C., 1990. Production frontiers, panel data, and time-varying technical inefficiency. *Journal of Econometrics*, 46(1-2), pp. 201-211.
- Kumbhakar, S. C., Ghosh, S. & McGukin, J. T., 1991. A generalized production frontier approach for estimating determinants of inefficiency in U.S. dairy farms. *Journal of Business & Economic Statistics*, 9(3), pp. 279-286.
- Kumbhakar, S. C. & Lovell, C. A. K., 2003. *Stochastic Frontier Analysis*. 1st ed. Cambridge: Cambridge University Press.
- Kumbhakar, S. C., Wang, H. J. & Horncastle, A. P., 2015. *A Practitioner's Guide to Stochastic Frontier Analysis Using Stata*. New York: Cambridge University Press.
- Kuppuswamy, V. & Villalonga, B., 2010. *Does Diversification Create Value in the Presence of External Financing Constraints? Evidence from the 2007-2009 Financial Crisis*. s.l.:Harvard Business School Finance Working Paper No. 10-101.
- Lamont, O., 1997. Cash flow and investment: Evidence from internal capital markets. *The Journal of Finance*, 52(1), pp. 83-109.
- Lang, L., Ofek, E. & Stulz, R. M., 1996. Leverage, investment, and firm growth. *Journal of Financial Economics*, 40(1), pp. 3-29.
- Lang, L. & Stulz, R. M., 1994. Tobin's Q, corporate diversification, and firm performance. *Journal of political economy*, 102(6), pp. 1248-1280.
- Lan, L. W. & Lin, E. T. J., 2006. Performance measurement for railway transport: Stochastic distance functions with inefficiency and ineffectiveness effects. *Journal of Transport Economics and Policy*, 40(3), pp. 383-408.
- Lee, Y. H. & Schmidt, P., 1993. A production frontier model with flexible temporal variation in technical efficiency. In: O. E. Harold, S. S. Schmidt & C. A. K. Lovell, eds. *The measurement of productive efficiency: Techniques and applications*. s.l.:Oxford University Press, pp. 237-255.
- Levinsohn, J. & Petrin, A., 2003. Estimating production functions using inputs to control for unobservables. *Review of Economic Studies*, 70(2), pp. 317-341.
- Lieberman, M. B. & Dhawan, R., 2005. Assessing the resource base of Japanese and U.S. auto producers: A stochastic frontier production function approach. *Management Science*, 51(7), pp. 1060-1075.
- Lovell, C. A. K., Travers, P., Richardson, S. & Wood, L., 1994. Resources and functionings: A new view of inequality in Australia. In: W. Eichhorn, ed. *Models and Measurement of Welfare and Inequality*. Berlin Heidelberg: Springer, pp. 787-807.
- Lovelock, C. H. & Wright, L., 2002. *Principles of Service Marketing and Management*. 2 ed. New Jersey: Prentice Hall.
- Lubatkin, M. & Chatterjee, S., 1994. Extending modern portfolio theory into the domain of corporate diversification: Does it apply?. *Academy of Management*

- Journal*, 37(1), pp. 109-136.
- Maksimovic, V. & Philips, G., 2008. Conglomerate firms and internal capital markets. In: B. E. Eckbo, ed. *Handbook of Corporate Finance: Empirical Corporate Finance*. North-Holland: North-Holland, pp. 423-479.
- Maksimovic, V. & Phillips, G., 2002. Do conglomerate firms allocate resources inefficiently across industries? Theory and evidence. *The Journal of Finance*, 57(2), pp. 721-767.
- Markides, C., 1995. Diversification, restructuring and economic performance. *Strategic Management Journal*, 16(2), pp. 101-118.
- Markides, C. C. & Williamson, P. J., 1994. Related diversification, core competences and corporate performance. *Strategic Management Journal*, 15(S2), pp. 149-165.
- Matsusaka, J. & Nanda, V., 2002. Internal capital markets and corporate refocusing. *Journal of Financial Intermediation*, 11(2), pp. 176-211.
- McGuinness, T. & Thomas, D., 1997. The diversification strategies of the privatised water and sewerage companies in England and Wales: A resource based view. *Utilities Policy*, 6(4), pp. 325-339.
- McGuinness, T. & Thomas, D., 1997. The diversification strategies of the privatised water and sewerage companies in England and Wales: A resource based view. *Utilities Policy*, 6(4), pp. 325-339.
- Meeusen, W. & van den Broeck, J., 1977. Efficiency estimation from Cobb-Douglas production functions with composed error. *International Economic Review*, 18(2), pp. 435-444.
- Meyer, M., Milgrom, P. & Roberts, J., 1992. Organizational prospects, influence costs, and ownership changes. *Journal of Economics and Management Strategy*, Volume 1, pp. 9-35.
- Miller, D. J., 2006. Technological diversity, related diversification, and firm performance. *Strategic Management Journal*, 27(7), pp. 601-619.
- Mizutani, F., 2006. The role of private provision in transport markets: Effects of private ownership and business diversification. In: K. Kobayashi, T. R. Lakshman & W. P. Anderson, eds. *Structural Change in Transportation and Communications in the Knowledge Society*. s.l.:Edward Elgar Publishing, pp. 227-247.
- Mizutani, F., Kozumi, H. & Matsushima, N., 2009. Does yardstick regulation really work? Empirical evidence from Japan's rail industry. *Journal of Regulatory Economics*, 36(3), pp. 308-323.
- Modigliani, F. & Miller, M. H., 1958. The cost of capital, corporation finance and the theory of investment. *The American Economic Review*, 48(3), pp. 261-297.
- Montgomery, C. A., 1982. The measurement of firm diversification: Some new empirical evidence. *Academy of Management*, 25(2), pp. 299-307.
- Montgomery, C. A., 1994. Corporate diversification. *Journal of Economic Perspectives*, 8(3), pp. 163-178.
- Montgomery, C. A. & Wernerfelt, B., 1988. Diversification, ricardian rents, and Tobin's q. *RAND Journal of Economics*, 19(4), pp. 623-632.
- Mueller, D., 1972. A life cycle theory of the firm. *The Journal of Industrial Economics*, 20(3), pp. 199-219.

- Murphy, K. J., 1985. Corporate performance and managerial remuneration: An empirical analysis. *Journal of Accounting and Economics*, 7(1-3), pp. 11-42.
- Nayyar, P. R., 1990. Information asymmetries: A source of competitive advantage for diversified service firms. *Strategic Management Journal*, 11(7), pp. 513-519.
- Nayyar, P. R., 1992. On the measurement of corporate diversification strategy: Evidence from large U.S. service firms. *Strategic Management Journal*, 13(3), pp. 219-235.
- Nayyar, P. R., 1993. Performance effects of information asymmetry and economies of scope in diversified service firms. *Academy of Management Journal*, 36(1), pp. 28-57.
- Nesta, L., 2008. Knowledge and productivity in the world's largest manufacturing corporations. *Journal of Economic Behavior & Organization*, 67(3-4), pp. 886-902.
- Newman, C. & Matthews, A., 2006. The productivity performance of Irish dairy farms 1984-2000: A multiple output distance function approach. *Journal of Productivity Analysis*, 26(2), pp. 191-205.
- Normann, R., 2001. *Service Management: Strategy and Leadership in Service Businesses*. 3rd ed. New York: Wiley.
- OFWAT, 2006. *The development of the water industry in England and Wales*. [Online] Available at: <http://www.ofwat.gov.uk/publication/the-development-of-the-water-industry-in-england-and-wales/>
- OFWAT, 2015. *Towards Water 2020 - policy issues: promoting markets*. [Online] Available at: <http://www.ofwat.gov.uk/publication/towards-water-2020-policy-issues-promoting-markets-2/>
- Olley, G. S. & Pakes, A., 1996. The dynamics of productivity in the telecommunications equipment industry. *Econometrica*, 64(6), pp. 1263-1297.
- Palepu, K., 1985. Diversification strategy, profit performance and the entropy measure. *Strategic Management Journal*, 6(3), pp. 239-255.
- Palich, L. E., Cardinal, L. B. & Miller, C. C., 2000. Curvilinearity in the diversification–performance linkage: an examination of over three decades of research. *Strategic Management Journal*, 21(2), pp. 155-174.
- Park, T. A. & King, R. P., 2007. Evaluating food retailing efficiency: The role of information technology. *Journal of Productivity Analysis*, 27(2), pp. 101-113.
- Paul, C. J. M. & Nehring, R., 2005. Product diversification, production systems, and economic performance in U.S. agricultural production. *Journal of Econometrics*, 126(2), pp. 525-548.
- Paul, C. J. M. & Nehring, R., 2005. Product diversification, production systems, and economic performance in U.S. agricultural production. *Journal of Econometrics*, 126(2), pp. 525-548.
- Peyer, U., 2002. *Internal and External Capital Markets*. INSEAD: Available at SSRN: <http://ssrn.com/abstract=309746> or <http://dx.doi.org/10.2139/ssrn.309746>.
- Piesse, J. & Thirtle, C., 2000. A stochastic frontier approach to firm level efficiency, technological change, and productivity during the early transition in Hungary. *Journal of Comparative Economics*, 28(3), pp. 473-501.
- Pitt, M. M. & Lee, L. F., 1981. The measurement and sources of technical inefficiency in the Indonesian weaving industry. *Journal of Development Economics*, 9(1),

pp. 43-64.

- Porter, M. E., 1980. *Competitive Strategy: Techniques for Analysing Industries and Competitors*. New York: Free Press.
- Porter, M. E., 1985. *Competitive Advantage*. 1st ed. New York: Free Press.
- Prahalad, C. K. & Bettis, R. A., 1986. The dominant logic: A new linkage between diversity and performance. *Strategic Management Journal*, 7(6), pp. 485-501.
- Rajan, R., Servaes, H. & Zingales, L., 2000. The cost of diversity: The diversification discount and inefficient investment. *The Journal of Finance*, 55(1), pp. 35-80.
- Reifschneider, D. & Stevenson, R., 1991. Systematic departures from the frontier: A framework for the analysis of firm inefficiency. *International Economic Review*, 32(3), pp. 715-723.
- Robins, J. & Wiersema, M. F., 1995. A resource-based approach to the multibusiness firm: Empirical analysis of portfolio interrelationships and corporate financial performance. *Strategic Management Journal*, 16(4), pp. 277-299.
- Rumelt, R. P., 1974. *Strategy, Structure, and Economic Performance*. Boston: Harvard Business School.
- Rumelt, R. P., 1982. Diversification strategy and profitability. *Strategic Management Journal*, 3(4), pp. 359-369.
- Russo, M., 1992. Power plays: Regulation, diversification, and backward integration in the electric utility industry. *Strategic Management Journal*, 13(1), pp. 13-27.
- Saito, T., 1993. *Private railways: Development of Japanese style railway management (Shitetsu sangyo: Nihongata tetsudo keiei no tenkai)*. Kyoto: Koyo Shobo (in Japanese).
- Scharfstein, D. S. & Stein, J. C., 2000. The dark side of internal capital markets: Divisional rent-seeking and inefficient investment. *The Journal of Finance*, 55(6), pp. 2537-2564.
- Schmidt, P. & Lin, T. F., 1984. Simple tests of alternative specifications in stochastic frontier models. *Journal of Econometrics*, 24(3), pp. 349-361.
- Schoar, A., 2002. Effects of corporate diversification on productivity. *Journal of Finance*, 39(6), pp. 2379-2403.
- Shin, H. H. & Stulz, R. M., 1998. Are internal capital markets efficient?. *The Quarterly Journal of Economics*, 113(2), pp. 531-552.
- Shleifer, A. & Vishny, R., 1989. Management entrenchment: The case of manager specific assets. *Journal of Financial Economics*, Volume 25, pp. 123-140.
- Shoji, K., 2001. *The Policy of Urban Public Transportation (Toshi Koukyou Koutsu Seisaku)* (in Japanese). Tokyo: Chikura Shobo.
- Shoji, K. & Killeen, B. J., 2001. A sketch of diversification strategy of Japanese 'minor' private railway companies (Chuushou Shitetsu no Takakuka Senryaku ni Tsuite: Yobiteki Kousatsu). *Journal of National Economics (Kokumin Keizai Zasshi)*, 184(5), pp. 1-16 (in Japanese).
- Smith, A. S. J., 2006. Are Britain's railways costing too much? Perspectives based on TFP comparisons with British Rail 1963-2002. *Journal of Transport Economics and Policy*, 40(1), pp. 1-44.
- Stein, J. C., 1997. Internal capital markets and the competition for corporate resources. *The Journal of Finance*, 52(1), pp. 111-133.

- Stein, J. C., 2003. Agency, information and corporate investment. In: G. M. Constantinides, M. Harris & R. M. Stulz, eds. *Handbook of the Economics of Finance*. North Holland: Elsevier, pp. 111-165.
- Stevenson, R. E., 1980. Likelihood functions for generalized stochastic frontier estimation. *Journal of Econometrics*, 13(1), pp. 57-66.
- Stimpert, J. L. & Duhaime, I. M., 1997. Seeing the big picture: The influence of industry, diversification, and business strategy on performance. *Academy of Management Journal*, 40(3), pp. 560-583.
- Stulz, R. M., 1990. Managerial discretion and optimal financing policies. *Journal of Financial Economics*, 26(1), pp. 3-27.
- Sugiyama, T., 2000. *Diversification strategy of major private railway companies: Existence of cross-traffic effect (Ote shitetsu kigyo no takakuka senryaku: Cross-traffic kouka no sonzai)*. Unpublished Master's Thesis, Kobe University (in Japanese).
- Takami, S., 2012. How effective internal capital markets have contributed to the reactions against the worldwide financial crisis caused by the collapse of Lehman Brothers? An analysis on 553 listed Japanese manufacturing firms [in Japanese]. *Japan Journal of Finance*, 32(1 & 2), pp. 2-22.
- Thompson, S., 1999. Increasingly marginal utilities: Diversification and free cash flow in newly privatized UK utilities. *Review of Industrial Organization*, 15(1), pp. 25-42.
- Villalonga, B., 2004. Diversification discount or premium? New evidence from the business information tracking series. *Journal of Finance*, 59(2), pp. 479-506.
- Ware, H., 1998. Competition and diversification trends in telecommunications: Regulatory, technological and market pressures. *Journal of Regulatory Economics*, 13(1), pp. 59-94.
- Whited, T. M., 2001. Is it inefficient investment that causes the diversification discount?. *The Journal of Finance*, 56(5), pp. 1667-1691.
- Wrigley, L., 1970. *Divisional Autonomy and Diversification*, Doctoral dissertation: Harvard University.
- Yokoyama, H., 2007. *Business Diversification Strategies in U.S. and Japanese Electric Utilities*, Harvard University: USJP Occasional Paper 07-16.
- Yoshida, S., 1986. Diversification in the transportation industry - the case of Japan (Kotsu jigyou no takakuka - Nihon no kotsu jigyo wo chushin ni). *Journal of Transportation and Economy (Unyu to Keizai)*, 46(4), pp. 27-36 (in Japanese).
- Yvrande-Billon, A., 2006. The attribution process of delegation contracts in the French urban public transport sector: Why competitive tendering is a myth. *Annals of Public and Cooperative Economics*, 77(4), pp. 453-487.