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Horizontal Mergers and Divestment Dynamics in a Sunset Industry

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Horizontal Mergers and Divestment Dynamics in a Sunset Industry*

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Abstract

In oligopolistic industries, the amount of capital investment is likely to be excessive due to the presence of a business-stealing effect and fixed costs. Similarly, sunset industries with declining demand tend to be riddled with chronic excess capital. The reason is that firms will attempt to free-ride on the reduction of industry supply expected from someone else's divestment, hoping to steal their business. This paper highlights the potential of mergers to internalize this business-stealing effect and thereby promote divestment. Using the case of mergers in the Japanese cement industry, it examines whether such merger-induced divestment improves total welfare. A dynamic model of divestment based on the Markov-perfect equilibrium framework of Ericson and Pakes (1995) is estimated and a counterfactual experiment is conducted to quantify the welfare impact of mergers. The findings suggest that merged firms indeed tended to close distribution centers more actively and that, as a result of these mergers, total welfare improved despite a reduction in the consumer surplus.

JEL Classification: L13, L41, L61
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1 Introduction

In so-called sunset industries that face declining demand, an important concern is how firms can reduce their capital stock to remain profitable. From an industry viewpoint, eliminating production or distribution facilities would be beneficial, since it would remove excess capital stock and thereby result in savings of the fixed costs associated with running these facilities, such as labor- and land-related costs.

Yet, in oligopolistic industries such divestment may not take place voluntarily. The reason is similar to the excess entry theorem discussed by Mankiw and Whinston (1986) and Suzumura and Kiyono (1987). The theorem suggests that in oligopolies the business-stealing effect and fixed costs result in an excessive number of entrants: entrants gain sufficient demand partly by stealing business from incumbent firms. While this is a gain to the entrants, it is not a gain to the industry and, in consequence, such entry is (socially) excessive.

This implies that in oligopolies there is a tendency for more investment to take place than the industry as a whole would want. Firms want to invest in capital up to the level where the marginal revenue from the next unit of capital just equals fixed costs. However, in oligopolies, part of that marginal revenue comes from the profits of competitors. This marginal revenue represents a gain only to the firm, not to other firms in the industry, and the total amount of capital stock as a result will be excessive, at least from the viewpoint of producers.[1]

In sunset industries, scrapping of capital stock may not take place for exactly the opposite reason: each firm is unwilling to divest because part of the business it abandons by scrapping is captured by its competitors. In other words, every firm intends to free-

[1]Okuno-Fujiwara and Suzumura (1993) show that in oligopolies of symmetric firms, cost-reducing investment such as R&D investment becomes excessive not only in terms of the producer surplus but also in terms of total welfare.

ride on the reduction of industry supply expected from someone else's divestment. The end result is that no firm will divest even though this would reduce fixed costs, thus prolonging the situation where there is excess capital stock.

The picture changes if two firms merge. A merger resolves the "deadlock" partly by internalizing the business-stealing effect. In a horizontal merger between firms A and B, post merger, A should have less incentive to maintain the same level of capital as before the merger because the stealing of business from B is now internalized and brings no gain to the merged firm. Therefore, mergers can promote divestment, providing fixed cost savings, and, as a result of that, enhance the profitability of merged firms even if it produces less than the two pre-merger firms together.[2] In fact, it is often observed that in industries that experience a negative demand shock, firms rush into mergers and subsequently rationalize their capital stock.[3]

However, a merger eliminates both capital stock and (at least) one competing unit. The reduction in the number of firms within the same industry is highly likely to be harmful to consumers. This anti-competitive effect may offset the efficiency improvement a merger can bring. This is a fundamental trade-off a merger causes (Williamson 1968). Thus, the change in industry structure and the adjustment of capital following a merger do not necessarily give rise to a higher level of total welfare. That is, from the viewpoint of total welfare, the problem is whether the efficiency gains from mergers, which include cost savings as a result of capital divestments as well as traditional synergy effects like a downward shift in the marginal cost curve, are greater than the

[2]Salant, Switzer, and Reynolds (1983) show that a reduction in output through internalization and the expansion of output by other firms make a merger nonprofitable unless there are synergies with regard to marginal costs. However, they also point out that even if the merged firm loses markets share, it can still save costs by shutting down a plant. Therefore, in the case of high fixed costs, the merger can be profitable.

[3]Fauli-Oller (2000) and Qiu and Zhou (2007) theoretically show that negative demand shocks (coupled with firm heterogeneities) are a key driver of mergers because the marginal cost reductions necessary to make a merger profitable are smaller at the time of a negative demand shock.

negative effect on the consumer surplus.[4] This implies that whether mergers with capital rationalization improve total welfare is an empirical question that depends on the magnitudes of the various effects. The purpose of this study is to conduct just such an empirical investigation, using the cement industry in Japan as a case study.

The Japanese cement industry provides a good case study for examining the welfare effect of mergers in a period of industry decline. Japan's cement industry can be regarded as a sunset industry in the sense that it has faced a prolonged downward trend in demand. Following the bursting of the bubble economy Japan experienced in the 1980s, public and private investment in construction, which is a good indicator of cement demand, decreased substantially during the 1990s and in recent years has settled at about the same level as that seen 30 years ago. As demand shrank, the industry was forced to contract in size and to become more efficient to survive in such severe circumstances. Around the mid-point of this phase of decline in the mid-1990s, four mergers and one acquisition took place. Following the mergers, physical capital in the industry, e.g., production plants and distribution centers, contracted along with the decline in demand. Whether this consolidation-induced contraction enhanced efficiency in the industry and improved welfare is the main point of interest in this study.

To evaluate the welfare effect of horizontal mergers, a theoretical model to capture the industry dynamics – namely the downward trend in demand and divestment of cement distribution centers – is constructed, building on the Markov-perfect equilibrium framework of Ericson and Pakes (1995).[5] The underlying parameters of the model

[4]Focusing on investment rather than divestment, Berry and Pakes (1993) investigated this effect of mergers on incentives for investment using a dynamic oligopoly model. They showed that a merger internalizes the effect of capacity expansion on the market price and that, in consequence, a merged firm has less incentive to engage in a capacity expansion race. One of the most interesting findings is that even if there is no synergy effect, the merger may be profitable and welfare improving in a dynamic environment.

[5]In recent years, the Ericson and Pakes model has been used extensively in both theoretical and empirical studies in the field of industrial organization. An excellent survey is provided by Doraszelski

governing divestment dynamics are estimated using the recently developed two-step estimator of Bajari, Benkard, and Levin (2007). With the parameter estimates thus obtained, a counterfactual experiment is then conducted to evaluate the welfare effect of the mergers.

The experimental exercise shows that the mergers improved total welfare, with most part of the welfare improvement coming from the gains in the producer surplus. The marginal cost functions of the merged firms shifted downward and the synergy effect stemming from this downward shift exceeded the loss in the consumer surplus. In addition to this efficiency gain in the traditional sense, merged firms tended to be more active in scrapping their distribution centers, and these divestments as a result of the mergers led to additional increases in cement firms' profits. Specifically, fixed costs savings and the realization of the sell-off values of distribution centers accounted for a non-negligible part of the total welfare improvement.

The novelty of this study is that it examines the effect of mergers on the forward-looking behavior of firms in the context of a declining industry and evaluates the welfare impact of such mergers in a dynamic environment. This study thus contributes to both the literature on the analysis of declining industries and that of mergers. Regarding the first of these two strands of literature, there have in fact been relative few studies on declining industries since the early theoretical work by Ghemawat and Nalebuff (1985, 1990), Fudenberg and Tirole (1986), and Whinston (1988), despite the fact that almost all developed nations have declining sectors and how to promote capacity reduction in such sectors is a pressing policy issue. Against this background, the present analysis is one of a handful studies on declining industries and will provide new empirical findings on industry contraction, with a particular emphasis on the role of mergers.

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and Pakes (2006).

The second strand of literature the present study relates to is that on mergers. The importance of modeling how a merger affects firms' incentives for investment, divestment, entry, and exit was first highlighted by Stigler (1968). Since then, a number of studies, including Berry and Pakes (1993), Gowrisankaran (1999), Pesendorfer (2005), and Choeng and Judd (2006), have proposed theoretical models addressing the effect of mergers. However, despite the blossoming of theoretical and computational work, only very few empirical studies on mergers from a dynamic perspective have been conducted. To the best of my knowledge, the present study is one of only a very few attempts to examine empirically the welfare implications of mergers by employing a fully dynamic model.

The remainder of the study is organized as follows. Section 2 reviews related empirical studies on declining industries and mergers. Section 3 provides a brief overview of the Japanese cement industry, while Section 4 explains the data used in this study. Next, Section 5 presents a theoretical model describing competition in the cement industry. It allows for capital divestment as well as traditional quantity-setting competition, building on the Markov-perfect equilibrium framework of Ericson and Pakes (1995). Section 6 then presents the empirical procedure. The structural parameters of the model are estimated using the econometric method recently developed by Bajari, Bankard, and Levin (2007). Section 7 provides the estimation results. This is followed, in Section 8, by a simulation experiment to evaluate the effect of the mergers in the Japanese cement industry on total welfare. By solving the model in both actual and counterfactual environments with the estimated parameters of the model, it is examined whether the mergers promoted divestment and total welfare was improved. Finally, section 9 concludes.

2 Related Studies

The current study is closely related to various previous empirical studies on declining industries and mergers. There are only a few empirical studies to date that have focused on declining industries. These can be classified into two categories according to the econometric methodology they employ: studies using structural econometric models, and studies using descriptive econometric models. An example of studies using structural econometric models is Takahashi (2014). He generalizes Fudenberg and Tirole's (1986) model to analyze the exit decision in oligopolies and develops a novel approach for estimating the exit game. Focusing on the US movie theater industry, the main interest in his study is in the timing of exit and, in particular, how strategic interactions among movie theaters delayed the exit date. He finds that strategic interactions substantially delayed exit dates compared to the dates that would maximize the industry's total profit.

The second category of empirical studies on declining industries include those by Lieberman (1990), Deily (1991), Gibson and Harris (1996), Bernard and Jensen (2007), and Nishiwaki and Kwon (2013). These studies are more descriptive in nature, examining plants' or firms' exit and capacity reduction decisions and focusing on understanding how plant or firm characteristics, including plant or firm productivity, affect exit and capacity reduction decisions. An obvious but important finding common across these studies is that low productivity plants and firms are more likely to shrink in size and to exit. This result confirms that productivity is one of the key forces shaping industry structure.

Next, turning to empirical studies on mergers, these can be divided into studies from a static and from a dynamic perspective. Recent studies from a static perspective include Nevo (2000), Pesendorfer (2003), Pinkse and Slade (2004), Ivaldi and Verboven

(2005), and Jeziorski (2014a). The studies take a static perspective in the sense that they do not consider dynamic decision problems such as entry, exit, investment, and divestment, and do not involve dynamic programming problems, although firms are assumed to be forward-looking. Of these studies, the one most closely related to the present study is that by Pesendorfer (2003). He develops a simple investment model reflecting competition in the US paper industry. While his model is inherently static and does not involve a dynamic programming problem, it succeeds in capturing the dynamic aspects of investment decisions in the industry and evaluating the welfare effect of mergers in the industry.

On the other hand, dynamic analyses of mergers are still rare. Notable exceptions are the studies by Jeziorski (2014b) and Benkard, Bodoh-Creed, and Lazarev (2010).[6] Jeziorski (2014b) examines ownership consolidation in the US radio industry after the Telecommunications Act. The main goal of his study is to estimate the extent of cost-side efficiency improvements brought about by the consolidation and to break down such improvements into the result of economies of scale, which depend on the number of stations owned by a single owner, and within-format synergies, which depend on the number of radio stations broadcasting a particular format. An empirical difficulty he tackles is that owners change the number of stations and decide their portfolio of formats endogenously. To deal with this endogenous acquisition decision problem, he observes the relatively simple pattern of acquisitions in the industry and develops an empirically tractable model of a sequential-move station-acquisition game where the biggest owner moves first. Based on his estimates, he concludes that the industry saved US$1.2 billion in fixed costs as a result of the consolidation following the Telecommunications Act.

[6]Another is that by Myojo and Ohashi (2009), who investigate a merger in the Japanese steel industry.

Another dynamic analysis of mergers is provided by Benkard, Bodoh-Creed, and Lazarev (2010), who consider the effect of mergers on entry and exit decisions. Specifically, they analyze potential mergers in the US airline industry and the effects of these on major carriers' and low cost carriers' (LCC) entry and exit decisions for city-pair routes. One of the most interesting findings is that, in the long run, other major carriers would respond to these mergers by entering more routes, while in the short run (at the time of the mergers) these mergers would increase the concentration on hubs. In addition, one of the three potential mergers would prompt LCCs to enter more routes in response to the merger.

3 The Cement Industry in Japan

This section provides a brief overview of trends in Japan's cement industry, the mergers that took place in the mid-1990s, and the effect of these mergers on regional markets.

3.1 Trends in the Japanese Cement Industry

The Japanese cement industry provides a good case study for examining the welfare effect of mergers in a period of industry decline. Figure 1 depicts the trends in cement consumption and government and private investment in construction. Cement is the key ingredient of concrete, which is used as construction material for skyscrapers, roadways, railways, airports, seaports and other infrastructure. Cement consumption thus mainly depends on the amount of construction investment in the private and public sectors, as can be seen in Figure 1. Cement consumption in Japan increased steadily from the 1980s and expanded until the bursting of the bubble economy. Since then, it has declined substantially as construction investment shrank and, in 2010, reached a level of around 70% of its peak and the same level as 30 years ago.[7]

As demand shrank, the cement industry began to contract by reducing its capital stock. The second column in Table 1 shows the remarkable reduction in the number of cement distribution centers during the period. Distribution centers, called "service stations," connect cement plants with local customers and as such play a key role in the cement supply chain in Japan. Once cement is produced in a plant, it is typically delivered by ship to service stations in regional markets.[8] Most (about 80%) of cement service stations are located along the coast and all service stations have silos for cement storage.

There are 11 regional markets in Japan: Hokkaido, Tohoku, Northern and Southern Kanto, Hokuriku, Tokai, Kansai, Chugoku, Shikoku, Kyushu, and Okinawa. Cement firms conduct business in some or all of these regions and have local headquarters responsible for sales activities in the regional markets. Within an individual region, a cement firm carries its product from its service stations to local consumers by truck. This stage of the transportation from service stations to consumers is called "secondary-stage delivery," whereas transportation from plants to service stations is "primary-stage delivery."

The costs of 'primary-stage delivery,' i.e., transportation costs by sea, are relatively

[7]Construction investment has been increasing since 2011, which appears to be contradict to the fundamental presumption of this study: the Japanese cement industry is a declining industry. However, most of this increase in construction investment very likely is due to the construction following the earthquake that struck some prefectures in the Tohoku and Kanto regions in March 2011: in response to the earthquake, the Japanese government decided on a major reconstruction program spanning several years, and more importantly, on plans to make all of Japan's cities earthquake-resistant. This increase as a result of the earthquake was clearly an unexpected demand shock for cement firms. Further, cement firms continued to reduce plant capacity by divesting their plants (and kilns, which are the most important facilities for cement production,) even after the earthquake (2011 and 2012). This shows that cement firms perceive their industry to still face a downward trend in demand (or at least they do not expect cement demand to recover greatly). It is therefore safe to assume that the Japanese cement industry is a declining industry.

[8]Cement plants tend to be located where there are abundant reserves of limestone. This means that in Japan, the Chugoku, Hokkaido and Kyushu areas account for an overwhelming proportion (about 60%) of cement production.

low, making it viable to deliver cement to (service stations in) regional markets far from the place of production. For example, a plant in Kyushu, the southernmost part of Japan, can ship its output to service stations in Hokkaido, the northernmost prefecture, at relatively little cost. This means that a plant can deliver its product to anywhere in Japan if it has a service station there.[9]

On the other hand, the transportation costs of the secondary stage are sufficiently high to prevent firms from delivering their product to customers far from a service station. To avoid long-haul carriage, cement firms set up several service stations within a regional market, and the number of service stations a firm has in a market, through its effect on transportation costs, is an important determinant of the firm's supply quantity.[10]

The more service stations a firm has, the more it can supply. At the same time, though, operating a service station also involves considerable variable and fixed costs. Such costs include, for example, the cost of maintaining a fleet of cement trucks for deliveries, primary-stage delivery costs, which depend on the number of service stations, and (minimum) labor costs to operate the service station, and other costs such as costs for running silos to keep cement dry when it is stored in the service station. Given these variable and fixed costs, a decline in demand creates pressure to reduce the number of service stations, and the need to eliminate service stations surplus to requirement in order to restore profitability was one of the key drivers underlying consolidation of the

[9]Most of plants are located in coastal areas while some plants are located in inland areas. Plants located inland may have a transportation cost disadvantage over plants in coastal areas, because, to deliver cement to regions far from plants, they have to use railways to deliver cement to the nearest port. The use of railways results in additional transportation costs and the distances that these plants deliver their output may consequently be shorter than those of plants in coastal areas.

[10]In addition to customers' concrete plants, cement firms deliver their product also to customers' construction sites. This means that they face uncertainty with regard to the distance from their service stations to construction sites. Because of this nature of cement delivery, it is likely to be advantageous for firms to have several distribution centers in a regional market.

cement industry.

3.2 Mergers

In the 1990s, faced with shrinking demand, the Japanese cement industry experienced mergers which accelerated market consolidation. Table 2 presents a list of mergers during this period. All of the mergers except Mitsubishi Cement Corp.'s acquisition of Tohoku-Kaihatsu Corp. changed market structure in at least one regional market, and the two mergers in 1998 in fact affected all regional markets by reducing the number of operating firms in all regional markets.[11]

Table 3 shows that as a result of the mergers, the number of firms operating in a particular region fell from an average of roughly nine to about six. Not only did the mergers reduce the number of firms, they also changed the concentration ratio accordingly, as is revealed in Table 4. This shows that the three-firm concentration ratio (CR3) in terms of the number of service stations rose nearly 15 percentage points following the first round of mergers in 1994 and, on average, exceeded 80% after the second round of the mergers in 1998.

Price is also an important factor in evaluating the effect of mergers. The last column in Table 1, presenting the trend in cement price from 1991 to 2009, shows that even after the big mergers in 1994 and 1998, the cement industry continued to experience falling prices. While one would usually expect prices to rise in response to a contraction in supply capacity as a result of mergers, what this trend suggests is that the continuing decline in demand more than offset any such effect. Thus, in examining how the mergers influenced prices, it is necessary to take this exogenous

[11] In this context, it should be noted that Ube-Mitsubishi Cement Corp. started as a firm that initially only merged the sales and distribution divisions of Ube Cement Corp. and Mitsubishi Cement Corp. in 1998 and combined all other divisions in 2000. This paper deals with Ube-Mitsubishi Cement Corp. as a merged firm during the entire observation period because the focus is on cement firms' supply behavior in a regional market.

trend in demand into account and to separate it from the effect of the mergers.

As mentioned above, a substantial reduction in the number of cement distribution centers was observed following the mergers. This is shown in the third and fourth columns in Table 1, which shows the steady decline in the total number of service stations and, moreover, illustrates that most of the reductions between 1998 and 2009 were undertaken by the firms that merged. The merged firms scrapped 125 service stations during this period while non-merged firms scrapped only 25 service stations. This suggests that the mergers may have affected the firms' incentives for scrapping their service stations and prompted the reduction in the total number of service stations.

The developments described here regarding the decline in demand and the downward trend in the number of service stations indicate that it is important to explicitly consider the constantly changing environment when evaluating the effects of the mergers. Failure to consider the dynamics of the Japanese cement industry arising from endogenous and exogenous factor will result in erroneous conclusions regarding the merger during this period of decline.

4 Data

A key objective of this study is to analyze how the mergers affected the incentive for divesting cement distribution centers, service stations, and whether the merger-induced divestment improved total welfare. To this end, data covering the period from 1998 to 2009, that is the period *following* the merger wave, is used. The data used in this study are collected from the *Cement Yearbook*(*Cement Nenkan* in Japanese), which is published annually by Cement Shimbun Co. Ltd, SNA statistics, and the National Survey of Prices. The *Cement Yearbook* provides useful firm-level and regional-level information on, e.g., the number of firms' service stations in an individual regions, and firms' quantity of supply in a region, and regional-level cement prices. On the other hand, the SNA statistics provide data on the amount of public and private investment in construction, which is a key determinant of cement demand, and regional GDPs, which can be considered to influence the sell-off value of service stations and the National Survey of Prices provide regional fuel prices, which influence cement delivery cost within a region.

According to the Japan Cement Association, the cement market in Japan is divided into 11 regional markets, consisting of the Hokkaido, Tohoku, Northern and Southern Kanto, Hokuriku, Tokai, Kansai, Chugoku, Shikoku, Kyushu, and Okinawa regions. This study focuses on six of these regional markets: Hokkaido, Tohoku, Tokai, Kinki, Chugoku, and Shikoku. The reason is that for the five other markets, either price information is not available (Hokuriku and Okinawa), the average size of service stations is very different from that of other markets (Southern Kanto and Kyushu), or both (Northern Kanto).[12]

Summary statistics of the data used in the following sections are provided in Table 5. Price is the annual average cement price in an individual regional market, expressed in yen per ton. Consumption is the total amount of annual consumption in an individual regional market, expressed in tons. Construction Inv. is the total amount of private and government investment in construction in Japan as a whole and is measured in billion yen. Regional GDP is regional real gross domestic product, in billion yen and Gas price is the mean of regional gas prices. Quantity is the quantity supplied by a firm in an individual region, expressed in tons. No. SS is the number of service stations of a

[12]Specifically, the average size of service stations in Northern Kanto is considerably larger than in the rest of the country, while the number of service stations is very small. On the other hand, in the Kyushu region, the situation is exactly the opposite. While investigating the reasons for these differences is beyond the scope of this study, they imply that the sell-off value of service stations in these regions would be very different from that of service stations in other regions.

firm in an individual region, and Divestment represents the number of service stations scrapped by a firm in a region.

To ensure the estimation, details of which will be explained later, the analysis focuses on the activities of the largest five firms in an individual market. This means that relatively small firms are excluded from the sample. However, the total amount supplied by these selected large firms accounts for at least 85% of the total supply in a regional market at any given time, and the average is more than 95% during the observation period. Therefore, focusing only on the largest firms will not have a substantial impact on the results of the analysis.

5 Model

To assess the welfare effect of the mergers, it is necessary to construct a theoretical model that captures the features of the cement industry. As previously noted, individual cement markets are localized and concentrated, and the product can be regarded as a homogeneous good. Further, the industry has been facing a downward trend in demand and cement firms have been forced to divest cement distribution centers, service stations (SSs for brevity hereafter), to remain profitable. While selling off some of its SSs allows a cement firm to realize the sell-off value of such distribution centers and to save fixed costs, part of its business will be stolen by competitors unless an SS is completely idle before being scrapped. Thus, strategic interaction between cement firms in a regional market is one of the key determinants of their divestment decisions. In addition, it is natural to assume that scrapping an SS has a dynamic impact on future market configurations: doing so will change not only the number of an individual firm's SSs in the subsequent periods but also the entire state of the market through strategic interaction among firms. As a result, the stream of future cash flows depends on divestment in the current period. Therefore, in deciding whether to scrap SSs, a cement firm will contemplate the influence of its action on the future market structure.

Given these industry characteristics —competition in a homogeneous product market, the dynamic decision regarding divesting SSs and the exogenous demand shift—, a model of oligopolistic competition in a dynamic environment is needed. Ericson and Pakes (1995) provide an elegant dynamic oligopoly framework designed to capture industry dynamics with heterogeneous firms. Building on their Markov-perfect equilibrium framework, a dynamic model of SS divestment is constructed here.[13]

In the model, each firm is characterized by only its state variables, and a regional market is completely described by a state vector consisting of firms' state variables, an exogenous demand shifter, and regional economic conditions. At the beginning of each period, firms decide simultaneously whether to scrap any SSs, and if they do so, choose the number of SSs scrapped, given their beliefs regarding future market configurations. Following the divestment decisions, product market competition takes place. Given their SSs, a demand shifter, and their competitors' strategies, firms compete with each other in terms of quantity. At the end of the period, each firm earns a profit as a result of product market competition and receives the sell-off value of SSs sold, which depends on regional economic conditions. The state variables evolve as the divestments are completed and new values regarding demand and regional economic conditions are realized.

In contrast to the original model of Ericson and Pakes (1995), in which investment is a continuous variable (but the state variables are still discrete), the present analysis has to consider discrete divestment actions because an SS is indivisible. This discrete nature of the divestment behavior may cause an equilibrium existence problem, as Doraszelski

[13]The model can be regarded as a simplified version of the model by Besanko, Doraszelski, Lu and Sattherthwaite (2010), which allows for both investment and divestment actions in dynamic oligopoly.

and Satterthwaite (2010) point out. To avoid such a problem, the sell-off value of an SS is considered to be a random variable from the sell-off value distribution, and it is assumed that before firms take any actions, they observe the sell-off value for their SS privately. Other than ensuring the existence of an equilibrium, introducing a privately known sell-off value is justified for at least two further reasons. First, in the real world, firms face uncertainty regarding their competitors' actions since they do not have exact knowledge of their competitors' payoffs. Introducing a privately known random sell-off value into the model reflects this uncertainty. The other reason is more practical. A dynamic stochastic game with incomplete information can be estimated using the econometric methods developed recently by Aguirregabiria and Mira (2007), Bajari, Benkard, and Levin (2007), Pakes, Ostrovsky and Berry (2007), and Pesendorfer and Schidt-Dengler (2008), and is numerically tractable with the purification technique of Doraszelski and Satterthwaite (2010). With the advancements in the econometrics of dynamic game models and in numerical methods for computing equilibria in dynamic games, the underlying parameters of the model can be recovered from the observed data and, once the underlying parameters are at hand, a counterfactual experiment can be conducted. For these reasons, this study describes the competition in the cement industry as a dynamic discrete game with incomplete information.

5.1 States

The theoretical model developed here is used to describe the competition between cement firms in a regional market.[14] There are N cement firms in a region. A regional cement market is assumed to be completely characterized by payoff-relevant state vari-

[14]Cement firms typically organize their branch network on a regional basis, that is, the local manager of a cement firm is responsible for sales activities in that regional market. It is therefore assumed that local managers decide the supply quantity and make divestment decisions, and these decisions do not influence the decisions of local managers in other markets. In other words, this assumption means that regional cement markets are mutually independent.

ables. The list of state variables includes firms' state variables, exogenous demand and cost shifters, and the level of regional economic activity. A firm's state consists of the number of the firm's SSs in the regional market and the firm's marginal cost shifter. The number of SSs affects its marginal cost of supply and, consequently, as previously explained, substantially influences its profit. The firm-specific marginal cost shifter includes other factors influencing the firm's supply.[15] The demand shifter, that is, the amount of regional (public and private) construction investment in each period, is also payoff-relevant, because firms' profits depend on demand conditions. The fuel (gasoline) price is a payoff-relevant state variable, since firms deliver cement by truck, so that fuel is one of the main inputs in cement delivery. On the other hand, the level of regional economic activity, represented by regional GDP, influences the sell-off value of SSs, because it affects the land price in the region. The state vector in period t in a market is defined as

$$\varsigma_t = \big(\{s_{1t}, c_1\}, \{s_{2t}, c_2\}, ..., \{s_{Nt}, c_N\}, z_t, w_t, v_t\big), \tag{1}$$

where state variable s_{it} represents the number of firm i's SSs in the regional market in period t, c_i is the firm-specific marginal cost shifter, which is assumed to be time-invariant, z_t is the amount of regional construction investment in period t, which is a key determinant of cement demand, w_t is the fuel price in period t, and v_t is regional GDP, which influences the sell-off value of SSs in period t. The region subscript r is dropped for expositional simplicity.

[15] Other factors influencing a firm's cost efficiency include, for example, how efficiently management at local headquarters uses the distribution network within their region. They also include the location of a firm's plant or plants, which affects the transportation costs for primary delivery from the plant to service stations in the region and consequently influences the firm's delivery cost in the region. (During 1998-2009 plant shutdowns were conducted by firms that merged. However, such firms shut plants in regions where they had more than one plants. This means that even though firms shut down some plants, they still had other plants in the regional markets where such shutdowns occurred. Therefore, most part of the cost advantage in serving particular markets was preserved although the distances from a production site to a market may have increased somewhat.)

The number of a firm's SSs in the next period, $t+1$, depends on whether the firm sells one or more of its SSs in the current period, t. That is, if firm i scrapped d_{it} SSs, then its state variable in the next period, $t+1$, is given by

$$s_{it+1} = s_{it} - d_{it}, \tag{2}$$

where s_{it+1} is the number of firm i's SSs in period $t+1$.[16] This adjustment is assumed to take one year, and depreciation is not considered.

Demand shifter z_t moves stochastically to a lower level or remains at the current level. Regional fuel price w_t and regional GDP v_t also move stochastically, but they can go to a higher or lower level or remain at the same level. These three state variables are assumed to evolve exogenously.

Except for regional fuel price w_t and regional GDP v_t, the movement of the state variables s_{it} and z_t is weakly unidirectional. That is, they can only move to a lower state or remain in a current state. This reflects the fact that the cement industry faced a downward trend in demand and that cement firms have continued to reduce their number of distribution centers accordingly.[17]

5.2 Timing

In the model, firms' actions are all a function of the state variables at the beginning of a period. That is, each firm initially makes a divestment decision given its beliefs with regard to other firms' strategies and with regard to future market conditions, after observing the current demand and cost shifter and privately knowing the sell-off

[16] The terminal state of a firm's SSs is one because exit is not considered in this model.

[17] The unidirectional movement of state variables is often important. A sufficient condition for the uniqueness of equilibria in a dynamic stochastic game is that the reaction functions intersect once at every state and movements through the state space are unidirectional (Besanko, Doraszelski, Lu, and Satterthwaite 2010). In the model here, firms' state variable and demand shifter are unidirectional and multiple equilibria are therefore less likely to arise than in models where state variables move freely up and down.

value of its SSs. After all firms have made their divestment decisions, competition in the product market takes place, given the current state variables. At the end of the period, each firm earns the per-period profit from competition in the product market and receives the sell-off value of its SSs if it scrapped any SSs. Then, firms' state variables evolve following firms' divestments and the three exogenous state variables change.

The sequence of events in each period unfolds as follows:

1. Firms know the sell-off values of their SSs privately and observe the current demand and cost shifters.

2. Firms makes their divestment decisions simultaneously.

3. Given the current state variables, ς_t, firms compete with each other over quantity.

4. Firms obtain the per-period profits and receive the sell-off values if they sold off SSs.

5. The state variables evolve as the divestments are completed and new values of the exogenous variables are realized.

5.3 Cash flow

The per-period cash flow of firm i at state ς_t is composed of two terms: profits from the product market competition and the proceeds of any divestments. Thus, the per-period cash flow of firm i at state ς_t can be written as

$$\pi_i(\varsigma_t, \phi_{it}) = u_i(\varsigma_{it}, \varsigma_{-it}, z_t, w_t) + \phi_{it} d_{it}. \tag{3}$$

$u_i(\varsigma_{it}, \varsigma_{-it}, z_t, w_t)$ denotes firm i's profit from the product market, given its own state $\varsigma_i (= \{s_{it}, c_i\})$, the other firms' state ς_{-it}, and demand and cost shifters, z_t and w_t. ϕ_{it}

is the realized sell-off value of firm i's SS at period t. It is assumed that this can be written as

$$\phi_{it} = \mu v_t + (\kappa v_t)\nu_{it}, \tag{4}$$

where ν_{it} is a random variable drawn from the standard normal distribution and is independent across firms and time periods. This specification means that the mean and variance of the sell-off value distribution depend on the state variable v_t, which represents the regional GDP level. That is, a sell-off value is assumed to be a random variable drawn from a normal distribution with state-dependent mean μv_t and variance $(\kappa v_t)^2$.

5.4 Product Market Competition and Profits

Given the current state, ς_t, firms compete with each other for quantity in the product market. The product market profit of firm i at state $(\varsigma_{it}, \varsigma_{-it}, z_t, w_t)$ is written as follows:

$$u_i(\varsigma_{it}, \varsigma_{-it}, z_t, w_t) = P(Q_t)q_{it} - C(\varsigma_{it}, w_t, q_{it}), \tag{5}$$

where $P(Q_t)$ is the inverse demand function, $C(\varsigma_{it}, w_t, q_{it})$ is the cost function depending on the state variables, ς_{it} and w_t, and the quantity supplied by firm i in that period, q_{it}. An inverse demand function with constant price elasticity is assumed:

$$P(Q_t) = A_0 Q_t^{\alpha_1} z_t^{\alpha_2}, \tag{6}$$

where A_0 is a time-invariant region-specific effect on price.

As explained previously, the important cost factors are transportation costs, which are influenced by the number of SSs a firm has in a market, and the fixed costs of maintaining an SS. Thus, the cost function is expressed as a function of firm i's own state variables, $\varsigma_{it}(=\{s_{it}, c_i\})$, fuel price, w_t, quantity, q_{it}, and fixed cost, f_{ss}, as follows:

$$C(\varsigma_{it}, q_{it}) = c_i s_{it}^{\gamma_1} w_t^{\gamma_2} q_{it} + f_{ss} s_{it}. \tag{7}$$

If γ_1 is negative (and, in fact, it is estimated to be negative in a later section), marginal costs can decrease with the number of SSs a firm has. The lower marginal costs can be achieved mainly by better management of distribution across several SSs, since costly long-haul transportation can be avoided. Fixed cost f_{ss} is the sum of the flow costs of running an SS, which include the costs of the minimum labor input and of the equipment required to operate an SS, such as a fleet of cement delivery trucks. It is assumed that fixed cost f_{ss} is common to all firms in all regions and constant over time.

A Cournot–Nash equilibrium in the product market is assumed. For computational and empirical tractability, it is also assumed that the quantities set in the product market do not have any dynamic effect. This assumption is the so-called 'static–dynamic' breakdown, which means that quantities supplied in the current period do not affect any actions in the following periods. Due to this 'static–dynamic' breakdown, the per-period profit $u_i(\varsigma_t)$ can be computed off the algorithm for computing the equilibria of this dynamic divestment model.[18]

5.5 Value Functions and Divestment Decisions

Next, the decision process regarding scrapping cement distribution centers is considered. As a firm's divestment decision in a period affects market structure in the subsequent periods, it can change the stream of its future cash flows. It is natural to assume that firms' divestment decision is dynamic in nature and, thus, each firm makes its

[18]In other words, per-period profits can be treated as primitives of the model when computing equilibria.

divestment decision to maximize expected future cash flows, given its beliefs regarding competitors' actions and future market conditions.

To analyze the dynamic decision problem in such a complex environment, following Maskin and Tirole (2001), attention here focuses on pure Markov strategies. In Markov strategies, the past influences current actions only through its effect on the current state variables, which summarize the direct effect of the past actions on the current state. Formally, a Markov strategy, which maps state variables and a private shock into actions is expressed as $d_i = d(\varsigma, \phi_i), d_i \in D_i$. In this model, an action is divestment, and d_i indicates the number of SSs firm i scraps and is a discrete variable, owing to the indivisible nature of SSs.

Firm i's decision problem is to choose the number of its SSs to scrap in the current period, taking into consideration the effect on the future cash flow stream, given its belief regarding future market configurations. Then, the value function of firm i at state ς is defined recursively by the solution to the following Bellman equation:

$$\begin{aligned} V_i(\varsigma, \phi_i) \quad = \quad & \max_{d_i \in D_i} \Big\{ u_i(\varsigma_i, \varsigma_{-i}, z, w) + d_i \phi_i \\ & + \beta \sum_{\varsigma'_{-i}, z', w', v'} V_i\big(\{s_i - d_i, c_i\}, \varsigma'_{-i}, z', w', v'\big) g_i\big(\varsigma'_{-i}|\varsigma\big) q\big(z', w', v'|\varsigma\big) \Big\}, \end{aligned} \tag{8}$$

where β is the discount factor, and the summation is taken over the one-period reachable states of other firms, ς'_{-i}, and these of demand shifter, cost shifter and scrap value distribution shifter, (z', w', v'). $V_i(\varsigma'_i, \varsigma'_{-i}, z', w', v')$ is firm i's expected value function at state ς before observing the sell-off value of the SSs it has, and is defined as $V_i(\varsigma'_i, \varsigma'_{-i}, z', w', v') = \int V_i(\{s_i - d_i, c_i\}, \varsigma'_{-i}, z', w', v', \phi'_i) dF(\phi'_i; \mu v', (\kappa v')^2)$. $g_i(\varsigma'_{-i}|\varsigma)$ is firm i's perceived transition probabilities of the competitors' current state, ς_{-i}, to the next state of it, ς'_{-i}. This can be written as the product of firm i's beliefs regarding its competitors' actions d_{-i} at state ς:

$$g_i(\varsigma'_{-i}|\varsigma) = \prod_{-i} \sigma_i(d_{-i}|\varsigma). \tag{9}$$

$q(z', w', v'|\varsigma)$ is the transition probability of the current demand shifter z, the cost shifter w, and the regional GDP v to the next state, z', w' and v'.

To express the optimal divestment decision rule, let $W_i(d_i|\varsigma)$ be the weighted average of the expected value functions when firm i takes action d_i at the current state ς:

$$W_i(d_i|\varsigma) = \beta \sum_{\varsigma'_{-i}, z', w', v'} V_i(\{s_i - d_i, c_i\}, \varsigma'_{-i}, z', w', v') g_i(\varsigma'_{-i}|\varsigma) q(z', w', v'|\varsigma). \tag{10}$$

At the beginning of each period, firm i knows the sell-off value of its SSs privately, and it chooses the number of SSs to be scrapped in that period by comparing the sell-off value with the differentials in the future expected value functions resulting from divestment. This optimal decision problem is expressed in the following way:

$$d_i = \begin{cases} 0 \quad \text{if} \ \ W_i(0|\varsigma) - W_i(1|\varsigma) \geq \phi_i \\ a (1 \leq a < \bar{a}) \quad \text{if} \ \ W_i(a-1|\varsigma) - W_i(a|\varsigma) < \phi_i \leq W_i(a|\varsigma) - W_i(a+1|\varsigma) \\ \bar{a} \quad \text{if} \ \ W_i(\bar{a}|\varsigma) - W_i(\bar{a}-1|\varsigma) > \phi_i. \end{cases} \tag{11}$$

The difference between the $W_i(\cdot|\varsigma)$s denotes the cut-off point and $\bar{a}$ is the maximum number of SSs to be scrapped. If firm i receives a sell-off value below the first cut-off point, it does not do anything and stays in ς_i in the next period. Otherwise, divestment occurs according to the above decision rule (11). For example, if the sell-off value of firm i's SSs is beyond the first cut-off point but not above the second point, it divests only one SS. Alternatively, if it falls between the second and the third cut-off point, firm i scraps two SSs. Thus, the divestment decision rule is expressed in terms of the cut-off strategy depending on the private sell-off value and the expected value function differentials.

Alternatively, the cut-off decision rule can be expressed in terms of the probability that each action is taken. Let $P_i(d_i|\varsigma)$ be the probability that firm i divests d_i SSs in state ς:

$$P_i(d_i|\varsigma) = \begin{cases} \int_{-\infty}^{W_i(0|\varsigma)-W_i(1|\varsigma)} dF(\phi_i; \mu v, (\kappa v)^2) & \text{if } d_i = 0 \\ \int_{W_i(d_i-1|\varsigma)-W_i(d_i|\varsigma)}^{W_i(d_i|\varsigma)-W_i(d_i+1|\varsigma)} dF(\phi_i; \mu v, (\kappa v)^2) & \text{if } 1 \leq d_i < \bar{a} \\ \int_{W_i(d_i|\varsigma)-W_i(d_i-1|\varsigma)}^{\infty} dF(\phi_i; \mu v, (\kappa v)^2) & \text{if } d_i = \bar{a}. \end{cases} \tag{12}$$

The last remaining component of the model is the expected value function $V_i(\varsigma_i, \varsigma_{-i}, z, w, v)$. This can be obtained by integrating over ϕ_i on both sides of (8):

$$V_i(\varsigma) = u_i(\varsigma_i, \varsigma_{-i}, z, w) + \sum_{d_i} P(d_i|\varsigma)\Big\{d_i E[\phi_i|\varsigma, d_i] + \beta W_i(d_i|\varsigma)\Big\}. \tag{13}$$

$E[\phi_i|\varsigma, d_i]$ is the expectation of the sell-off value conditional on scrapping d_i SSs.[19] Once the expected value functions are at hand, firm i's optimal choice can be obtained by (11) or (12).

The continuous state variable ϕ_i is eliminated from the state variables vector by integrating it out. Expression (13) is very useful because the computational disadvantage created by the introduction of private information disappears and the equilibria are computable.

5.6 Equilibrium

To analyze equilibrium divestment behavior, attention is restricted to symmetric Markov-perfect Nash equilibria (MPE) because the model of product market competition developed here gives rise to symmetric profit functions. An MPE ensures that at each state, each firm chooses an optimal action given its beliefs regarding the future market

[19]The expected sell-off value equals $\mu v + \kappa v E[\nu_i|\varsigma, d_i]$, and $E[\nu_i|\varsigma, d_i]$ is calculated by

$$E[\nu_i|\varsigma, d_i] = \begin{cases} [P_i(d_i|\varsigma)]^{-1} \int \nu_i \cdot \mathbf{1}\left[\frac{W_{d_i-1}-W_{d_i}-\mu v}{\kappa v} < \nu_i \leq \frac{W_{d_i}-W_{d_i+1}-\mu v}{\kappa v}\right] d\Phi(\nu_i) & \text{if } 0 < d_i < \bar{a} \\ [P_i(d_i|\varsigma)]^{-1} \int \nu_i \cdot \mathbf{1}\left[\frac{W_{d_i}-W_{d_i-1}-\mu v}{\kappa v} < \nu_i\right] d\Phi(\nu_i) & \text{if } d_i = \bar{a}, \end{cases}$$

where W_{d_i} is $W_i(d_i|\varsigma)$.

structure, and those beliefs are consistent with the actions of other competitors. The divestment strategy profile $\mathbf{d}^*$ is an MPE if, for all firm i's states ς and strategies d_i',

$$V_i(\varsigma; \mathbf{d}^*) \geq V_i(\varsigma; d_i', \mathbf{d}_{-i}^*). \tag{14}$$

The existence of the MPE follows from the arguments in Doraszelski and Satterthwaite (2010).

5.7 Modeling Issues

Before moving to the next section, some modeling issues should be discussed. One of the modeling issues is that the theoretical model does not consider the merger decision itself.[20] (Given that the number of merger cases in the cement industry is very small, even if an endogenous merger model was developed, it would be difficult to estimate it.)

Not endogenizing the merger decision gives rise to potential problems. First, in the model, firms do not consider the possibility of mergers in making their divestment decisions: the probability (firms' expectation) of mergers is assumed to be zero in each period. In fact, there have not been any further mergers since the four mergers considered here. However, this does not necessarily mean that firms expected no more mergers to take place during the period 1998-2009, nor does it mean one can assume that firms did not consider the possibility of mergers in making their divestment

[20] In his study of the US radio industry, Jeziorski (2014b) develops an empirical model of endogenous mergers by modeling the merger decision process as a sequential-move game. In general, modeling the merger process as a sequential-move game is attractive, since it greatly reduces the theoretical and computational difficulties. However, for the mergers in the Japanese cement industry, employing such a sequential-move game would not be appropriate. The reason is that firms in the cement industry had to submit their merger proposals to the Japan Fair Trade Commission (JFTC), which took about a month on each occasion to investigate those merger proposals. Given that two of the mergers occurred in 1994 and two in 1998, and each time the gap between the two mergers in a year was only a month, i.e., the time it took for the JFTC to investigate and approve a merger proposal, it would be implausible to assume that firms were engaged in a sequential-move game. Thus, while Jeziorski's model seems appropriate for the US radio industry, this is not the case for the Japanese cement industry.

decisions.

Therefore, whether the model constructed accurately describes divestment behavior in the cement industry depends on (a) whether firms had expected (further) mergers to take place when they made divestment decisions, (b) if the probability of further mergers was not negligible, whether the potential impact of such mergers on the industry was expected to be negligibly small.

To examine these issues, the Herfindahl-Hirschman Index (HHI) provides a clue. The HHI in Japan's cement industry was already around 2,500, meaning that, during the period considered here, any merger between large firms, Taiheiyo, Ube-Mitsubishi, and Sumitomo Osaka, would have been unlikely to be accepted by the Japan Fair Trade Commission if such a merger had been proposed. On the other hand, with respect to mergers involving very small firms, the impact of these is negligibly small even if they occur.

Therefore, the only possible and potentially influential mergers that firms might have expected to take place are one between a large firm and a small firm and one between small firms. If firms had in fact expected such a merger or mergers to take place and taken the potential impact of these into account when they decided their divestments during the period considered here, firms' divestment behavior described in the model would differ from their actual behavior.[21] However, small firms tended to operate only in a small number of regional markets, so that their overlap with the operations of other small firms was limited. Thus, even if firms had expected such a merger or mergers involving smaller firms to take place, they would have expected them to affect not all regional markets.[22]

[21] For example, in some regions, a merger involving two small firms could have created a larger firm that is comparable to existing post-merger entities if it had taken place during the period considered here.

[22] Appendix B provides a more detailed discussion on the possibility of potential mergers and presents

The second issue arising from not endogenizing mergers is the possibility that it is particularly efficient (or particularly inefficient) firms that are involved in mergers, so that the model does not accurately capture the effect of a merger on divestment, which is one of the main interests of this study. This issue is relevant in conducting the counterfactual simulation analysis, where the model is used to create a counterfactual market structure without mergers.[23] The key issue is that if relatively inefficient firms were involved in a merger they would have divested their SSs even if the merger had not occurred. As a result, the effect of mergers on divestment must be overstated. However, this issue will be (at least partly) solved by introducing (time-invariant) firm-specific effects in the cost function, c_i. Differences in cost efficiency between firms are captured by firm-specific effects. This issue (and other issues relating to it) will be addressed in Section 8 (and Appendix A) again.

Yet, another issue not considered in the model is exit. During the observation period, there was only one firm, Mitsui Cement, which exited from the industry, in 2004. Mitsui Cement operated in four regions (three regions out of the six regions in the sample) and was only a very small player with a market share of no more than 2.7% in any region and at any one time, and it was not among the largest five firms in any region. All other firms which were present in a particular region in 1998 still operated in that region in 2009. Therefore, firms' exit decision is not considered here (although it would not be difficult to incorporate firms' exit decision in the model).[24]

an experimental exercise to assess the potential effects arising from ignoring potential mergers in the model, particularly on the estimation. The exercise examines whether and how not endogenizing the merger decision causes bias in the estimates of the (dynamic) structural parameters, fixed cost and the sell-off value distribution, and whether and how the potential bias affects the welfare analysis of mergers.

[23]The referees' comments on this issue were very helpful

[24]Another aspect that is not considered in the model but that potentially influences profits is production capacity. A firm's supply in a regional market may be bounded by the production capacity of its plants and not just by the supply capacity determined by its SSs. However, omitting production capacity is unlikely to cause a problem, given that the average capacity utilization rate was below

6 Estimation

The aim of this section is to estimate the underlying parameters governing the dynamics in the theoretical model. Target parameters can be divided into two types: static parameters and dynamic parameters. Static parameters govern static competition and determine per-period profits. These parameters, including the parameters of demand and cost functions, can be recovered without any difficulty by standard estimation techniques. On the other hand, as the dynamic parameters have to be inferred from firms' dynamic decision processes, estimation of these parameters, involving computing value functions, is computationally challenging. In particular, computing value functions in IO models is extremely burdensome, in terms of computation time, because it has to deal with strategic interaction among players. Therefore, although the standard estimation algorithms proposed by Rust (1987), which require computing fixed points that determine value functions at different trial parameter values, can be applied to single-agent dynamic decision problems, they are usually infeasible in multiple-agent settings.[25]

However, in recent years, innovative econometric techniques have been developed that can resolve the computational problem in estimating models of multiple agents' dynamic decision problems (see, e.g., Aguirregabiria and Mira 2007; Bajari, Benkard, and Levin 2007; Pakes, Ostrovsky, and Berry 2007; and Pesendorfer and Schmidt-Dengler 2008).[26] These techniques can avoid or mitigate the time-consuming value

80% during the observation period, implying that cement plants – at least on average – did not face any capacity constraints.

[25]There is another reason that the nested fixed point approach cannot be applied straightforwardly to the estimation of game theoretic models. The presence of multiple equilibria makes the econometric model of a game incomplete. That is, due to the presence of multiple equilibria, the estimation strategy, which searches for the parameter values that make the behavior implied by the economic model fit as close as possible to the observed behavior, cannot work because the relationship between the behavior implied by the model and the observed behavior is not one-to-one.

[26]Using these recently developed techniques, Ryan (2012) examines the effect of an environmental

function computations by applying to dynamic games a novel two-step estimator for the single-agent dynamic decision process of Hotz and Miller (1993). In this paper, to estimate the structural parameters, the simulation estimator proposed by Bajari, Benkard, and Levin (2007; hereafter BBL) is used. The basic procedure of the estimation involves the following two steps: (1) Under the assumptions that the observed data are generated from a single MPE profile, the equilibrium policy functions and the transition probabilities as well as the profit functions are estimated, and the equilibrium value functions are approximated by averaging many simulated paths generated by the estimated policy functions and transition probabilities. (2) The parameters of interest are set to satisfy the equilibrium conditions under which the value functions resulting from equilibrium strategies dominate the alternative value functions resulting from nonequilibrium strategies.

Let $V_i(\varsigma|\mathbf{d}(\varsigma,\phi);\theta)$ be the expected value function of firm i at state ς under the parameter values of θ, assuming firm i is following the Markov strategy d_i and rival firms are following strategy $\mathbf{d}_{-i}$. Then, the expected value function can be defined as the sum of the future values of cash flows $\pi_i(\varsigma_t,\mathbf{d}(\varsigma_t,\phi_t),\phi_{it};\theta)$ from starting state ς:

$$V_i(\varsigma;\mathbf{d}(\varsigma,\phi),\theta) = E\left[\sum_{t=0}^{\infty}\beta^t\pi_i(\varsigma_t,\mathbf{d}(\varsigma_t,\phi_t),\phi_{it};\theta)\big|\varsigma_0=\varsigma;\theta\right]. \tag{15}$$

The expectation is taken over the current and future private values ϕ_t and future states ς_t. Forward simulation approximates the above expected value function V_i by averaging many simulated paths of infinite future cash flow streams starting from ς. As will be explained, the optimal choice rule of firm i at state ς can be expressed by a function

regulation on cement producing plants in the US in a dynamic framework, while Collard-Wexler (2013), investigating entry and exit decisions in the US ready-mix concrete industry, analyze how demand fluctuations influence the market structure. Sweeting (2013) estimates switching costs in the US radio industry using a dynamic model of product repositioning and Dunne, Kilmek, Roberts and Xu (2013) analyze the determinants of market structure estimating a dynamic model of entry and exit. In a single agent set up, Holmes (2011) uses BBL's two-step estimator to quantify economies of density of Wal-Mart.

of the choice probabilities $\mathbf{P}_i(\varsigma) = (P_i(0|\varsigma), P_i(1|\varsigma), \ldots, P_i(\bar{a}|\varsigma))$, and therefore, value function V_i is also a function of the choice probabilities. By the definition of MPE, the equilibrium value functions must be greater than or equal to the value functions resulting from the alternative, nonequilibrium play $d_i'(\varsigma, \phi_i)$. Therefore, the following equilibrium condition should be satisfied at the vector of true parameter values θ_0:

$$V_i(\varsigma; \mathbf{d}^*(\varsigma, \phi), \theta_0) \geq V_i(\varsigma; d_i'(\varsigma, \phi_i), \mathbf{d}^*_{-i}(\varsigma, \phi_{-i}), \theta_0). \tag{16}$$

6.1 First-step Estimation

In the first step, the demand function and the cost function are estimated to obtain the parameters governing the quantity competition, and the per-period profits are obtained. Then, the equilibrium policy functions can be estimated from the observed equilibrium plays at each state. With these estimates, the equilibrium value functions can be calculated by averaging many simulated equilibrium paths.

6.1.1 Demand Function

The following log-linear demand function is estimated:

$$\ln(Q_{rt}) = \alpha_{0r} - \alpha_1 \ln(P_{rt}) + \alpha_2 \ln(z_{rt}) + \epsilon^d_{rt}, \tag{17}$$

where P_{rt} is the price at time t in region r, Q_{rt} is the quantity sold at time t in region r, and z_{rt} is the total amount of private and public construction investment at time t in region r. α_{0r} is a time-invariant region-specific demand shifter. Unobservable demand shocks ϵ^d_{rt} are assumed to be independently and identically distributed (i.i.d.) across time and region. The parameters of the demand function are estimated using two-stage least squares (2SLS), using the fuel price, a marginal cost shifter, as the instrumental variable for the price P_{rt}.

6.1.2 Cost Function

As cost-side variables are proprietary to firms and inherently difficult to obtain, straightforward estimation as in the case of the demand function is not possible. Therefore, to estimate the (marginal) cost function, it is necessary to impose an assumption as to how equilibrium in the product market is achieved.[27] The equilibrium concept used here is that of a Cournot–Nash equilibrium. In a Cournot game, each firm determines its quantity to maximize the per-period profit function, given other firms' quantities. Firm i's predicted marginal cost is derived from the first-order condition of the firm's profit maximization problem,

$$mc_{irt} = P_t(Q_{rt}) + \frac{\partial P(Q_{rt})}{\partial q_{irt}} q_{irt}. \tag{18}$$

Thus, having estimated the demand function, it is then possible to estimate the marginal cost function, which is assumed to depend on the number of SSs, s_{irt}, just as if it were observed. Using a logarithmic specification, the marginal cost of firm i is written as

$$\ln(\hat{mc}_{irt}) = \gamma_{0ri} + \gamma_1 \ln(s_{irt}) + \gamma_2 \ln(w_{rt}) + \epsilon^c_{irt}, \tag{19}$$

where γ_{0ri} is the logarithm of firm i's marginal cost shifter c_i. Unobservable cost shocks ϵ^c_{irt} are assumed to be i.i.d. across time, region, and firm, and, for simplicity, are not considered as a state variable.

Before proceeding to the estimation of the equilibrium policy functions, a clear drawback of this estimation approach should be noted. Namely, fixed cost f_{ss} cannot

[27] The approach of employing an equilibrium assumption to estimate cost function parameters is based on Bresnahan (1981). An alternative approach that does not require an equilibrium assumption has been proposed by Rosen (2007). Specifically, in his study of the Joint Executive Committee railroad cartel, he defines the lower and upper bounds for firms' marginal costs and estimates the parameters in the marginal cost function exploiting these lower and upper bounds. While such an approach is quite interesting, it is not pursued here.

be identified in this step, because it is dropped from the first-order conditions. Unfortunately, data on the minimum flow cost required for the annual maintenance of an SS were unavailable. Therefore, as explained in a later section, fixed cost is estimated in the second step.

6.1.3 Divestment Policy Functions

The last empirical objective in the first step is to estimate the equilibrium policy functions governing divestment behavior. The theoretical model suggests that the equilibrium policy functions should be a function of the current state variables and a random sell-off value. The divestment decision strategy is a cut-off strategy because of the indivisible nature of an SS. The cut-off strategy means that the policy functions are weakly increasing in ϕ_i rather than strictly increasing.

The estimation proceeds by first estimating from the data the choice probabilities of all possible actions of a firm at a state and then calculating the equilibrium cut-off points by inverting the standard normal distribution. These equilibrium cut-off points correspond to the equilibrium policy rule. Let $G_i(d_i|\varsigma)$ be the cumulative probability that firm i at state ς decides to scrap d_i or fewer SSs. Following the theoretical model, this cumulative distribution function can be written as

$$\begin{aligned} G_i(d_i|\varsigma) &= \int_{-\infty}^{W_i(d_i|\varsigma)-W_i(d_i+1|\varsigma)} dF(\phi;\mu v,(\kappa v)^2) \\ &= \int_{-\infty}^{\bar{W}_{id_i}(\varsigma)} d\Phi(\nu) \\ &= \Phi(\bar{W}_{id_i}(\varsigma)), \end{aligned} \tag{20}$$

where $\bar{W}_{id_i}(\varsigma)=\frac{W_i(d_i|\varsigma)-W_i(d_i+1|\varsigma)-\mu v}{\kappa v}$, which represents the normalized cut-off point at which firm i at state ς is indifferent between divesting d_i SSs and scrapping one unit more than d_i, and Φ denotes the normal cumulative distribution function. Inverting the above equation, the cut-off point can be expressed as a function of the probability

$G_i(d_i|\varsigma)$:

$$\bar{W}_{d_i}(\varsigma) = \Phi^{-1}(G_i(d_i|\varsigma)). \tag{21}$$

This normalized cut-off point can be interpreted as the equilibrium policy rule itself. For instance, when firm i knows that the (normalized) sell-off value of its SSs is below $\bar{W}_{i0}(\varsigma)$, it does not scrap any SSs. Alternatively, when firm i knows that the (normalized) sell-off value of its SSs falls between $\bar{W}_{i0}(\varsigma)$ and $\bar{W}_{i1}(\varsigma)$, it sells one SS. If the cut-off points of all possible actions of firm i at state ς are estimated, then how firm i will behave at the state can be easily predicted.

To estimate the equilibrium policy functions, this estimation approach needs only the estimates of the cumulative probabilities of firm i's actions at state ς, $\mathbf{G}_i(\varsigma) = (G_i(0|\varsigma), \ldots, G_i(\bar{a}|\varsigma))$. While an optimal estimator for $G_i(d_i|\varsigma)$ would be a simple nonparametric description of what firm i does at state ς, the choice probabilities are estimated parametrically using an ordered probit model.[28] This parametric approach is chosen over a nonparametric approach because of the sample size used in this study. The normalized cut-off points for all possible actions of firm i at state ς can be calculated by inserting the estimated probabilities of all possible action of firm i at state

[28]The maximum number of divestments of a firm depends on the firm's number of SSs currently held. Firms with two SSs have only two choices, one divestment or no divestment, firms with three SSs have three choices, one divestment, two divestments or no divestment, and firms with four SSs have four choices while firms with more than five SSs have five choices. Thus, compared to a usual ordered probit model, the log likelihood function must be modified in the following way:

$$lnL = \sum_{i=1}^{N_{ss=2}} \sum_{j=0}^{1} d_{ij} lnP_{ij} + \sum_{i=1}^{N_{ss=3}} \sum_{j=0}^{2} d_{ij} lnP_{ij} + \sum_{i=1}^{N_{ss=4}} \sum_{j=0}^{3} d_{ij} lnP_{ij} + \sum_{i=1}^{N_{ss\geq 5}} \sum_{j=0}^{4} d_{ij} lnP_{ij}$$

where $N_{ss=k}$ and $N_{ss\geq 5}$ are the number of firms with k SSs and the number of firms with more than five SSs, respectively, and d_{ij} is an indicator variable which takes one if firm i's number of divestments is j and zero otherwise. P_{ij} is the probability of firm i divesting j SSs. This modified ordered probit model allowing different choice sets for different firms is more appropriate than a regular ordered probit model. That being said, the results from a regular ordered probit model are not very different from the ordered probit model employed here, which are shown in Table 9. The reason is that $N_{ss=2}$, $N_{ss=3}$, and $N_{ss=4}$ are not very large.

Firms with only one SS are assumed to have no choice and hence are not included in the estimation of divestment probabilities, since exit is not considered in the theoretical model.

ς into the right hand side of equation (21), and the divestment behavior of firm i at state ς based on these cut-off points is determined by drawing a sell-off value from the normal distribution.

To estimate the equilibrium policy functions, all markets are pooled together due to the sample size. This estimation strategy requires that the same MPE profile is employed for all different markets. However, this means that this approach is likely to be problematic in the presence of multiple equilibria, because it rules out that different markets have different equilibrium profiles. The approach thus works only if the same equilibrium arises across different markets.[29]

To resolve this potential problem, BBL (2007) propose that one estimates the equilibrium choice probabilities in each market separately instead of pooling markets together. This solution would work very well if a long panel for each individual market (or a long panel for each firm in each market in the case where firms are allowed to have an unobserved (time-invariant) state variable) were available. However, since the panel in this study is not very long and comprises annual observations for only 12 years, directly employing their approach would be problematic. Instead of estimating the equilibrium choice probabilities in each market separately, the approach taken here is to introduce market effects as well as interaction terms of market effects and some state variables, in order to make the estimation as close as possible to the approach proposed by BBL(2007).[30] Market effects capture the different divestment probabilities arising in different markets.[31] The introduction of interaction terms allows state variables to affect the divestment probabilities differently in different markets, and thus helps to

[29]Otsu, Pesendorfer, and Takahashi (2014) propose a test for the presence of multiplicity. Unfortunately, the test cannot be applied here, since it basically exploits cross-sectional (market-level) observations and there are only six markets in this study.

[30]I am grateful to an anonymous referee for suggesting this alternative solution.

[31]Studies employing a similar approach include Ryan (2012), Collard-Wexler (2013), Dunne, Kilmek, Roberts, and Xu (2013), Suzuki (2013), and Sweeting (2013).

make the estimation as close as possible to the approach suggested by BBL (2007). While this approach may not completely deal with the potential problem arising from the presence of multiple equilibria, it helps to resolve it at least partly.[32]

6.1.4 Transition Probabilities of the Three Exogenous States

To estimate the transition probabilities of regional construction investment z, regional fuel price w and regional GDP v, these three continuous variables are first discretized. With regard to the transition probabilities of construction investment z, these probabilities are estimated using a binomial logit model. Since during the observation period construction investment was on a downward trend, the probabilities of moving to a lower state and staying at the current state are estimated.[33] On the other hand, fuel price w, and regional GDP v can go up or down or stay at the current level, so that the transition probabilities for these are estimated using a multinomial logit model.

The maximum (minimum) values of fuel price w and regional GDP v are set to the actual maximum (minimum) values of these in each region. Between these upper and lower limits, these variables move exogenously according to the transition probabilities.[34] On the other hand, the movement of regional construction investment is weakly unidirectional. To bound this unidirectional movement, the lower limit for construction investment in each region has to be set.[35]

Because it is difficult to determine the exact lower bound for each region and it

[32]An additional virtue of this approach is the following: even if there are no multiple equilibria or one equilibrium common to all regional markets is actually selected, it is still possible that the policy functions may be misspecified.; introducing interaction terms reduces the bias arising from such misspecification.

[33]Specifically, construction investment increased from the previous year's level only twice during the period considered here. These increases can be regarded as clearly temporary and therefore are categorized as "staying at the current state."

[34]The numbers of discrete grids for regional GDP are 4 for Chugoku, 2 for Hokkaido, 3 for Kinki, 2 for Shikoku, 3 for Tohoku, and 5 for Tokai while those of grids for fuel price are 3 for all regions.

[35]The course of construction investment is assumed to be as the following: it falls from the current state to the lower limit stochastically and remains at this level forever.

seems inappropriate to employ a particular value of the lower bound for the demand level, several alternative lower bounds are considered. The first lower bound is the level of construction investment in 2009. Compared to the other two alternatives, this lower bound is an optimistic one, although it is based on the actual trend in cement consumption. The second lower bound is a pessimistic one and is half of the level of construction investment in 2009. This would be more or less equivalent to the level of construction investment in 1965, the year when government spending started to play a more important role in Japan's rapid growth. The third lower bound is the intermediate between the first and second lower bounds.[36]

6.1.5 Value Functions

As the equilibrium value functions can be used to estimate the dynamic structural parameters in the next step, they are the most important ingredients in this estimation approach. The expected value function of a state is estimated by averaging many simulated paths, starting from the state with the estimated policy functions. This technique, known as forward simulation, was originally utilized by Hotz, Miller, Smith and Sanders (1994) and was extended to multiple agents' decision problems by BBL (2007).

Given a starting state, each simulation path is generated using the following steps:

1. Set a starting state $\varsigma_0 = \varsigma$.

2. Draw normalized sell-off values ϕ_{i0} and ϕ_{-i0} from the standard normal distribution and determine actions d_{i0} and d_{-i0}.

[36]The numbers of discrete grids for construction investment are 5 for Chugoku, 7 for Hokkaido, 4 for Kinki, 7 for Shikoku, 6 for Tohoku and 3 for Tokai in the optimistic scenario. In the intermediate scenario, the numbers of grids are 8 for Chugoku, 9 for Hokkaido, 10 for Kinki, 7 for Shikoku, 10 for Tohoku, 6 for Tokai while those are 10 for Chugoku, 12 for Hokkaido, 9 for Kinki, 11 for Shikoku, 11 for Tohoku, and 8 for Tokai in the pessimistic scenario.

3. Calculate the per-period cash flow $\pi_i(\varsigma_0)$.

4. Update the current state, $(\varsigma_{i0}, \varsigma_{-i0}, z_0, w_0, v_0)$, following the divestment decisions and the transition probabilities of these two exogenous variables to a new state, $(\varsigma_{i1}, \varsigma_{-i1}, z_1, w_1, v_1)$.

5. Repeat steps 1–4 for T periods.

The equilibrium value functions are estimated by averaging 1000 simulated paths constructed in the above manner. Each path has a length of 100 periods, and the discount factor β is set at 0.925. The expected value function of firm i starting from ς can be approximated by

$$\frac{1}{H}\sum_{h=1}^{H}\left[\sum_{t=0}^{\infty}\beta^t\hat{\pi}_i^h(\varsigma_t, \hat{\mathbf{d}}(\varsigma_t, \phi_t), \phi_{it}; \theta)|\varsigma_0 = \varsigma; \theta\right]. \tag{22}$$

H is the number of draws from the standard normal distribution.[37]

6.2 Second-step Estimation

In the second step, the dynamic structural parameters, which are the mean and variance of the sell-off value distribution, and the fixed costs are estimated. In this estimation,

[37]To reduce the computational burden, the linearity assumption in the payoff function is exploited. Recall that the per-period cash flow of firm i at state ς is

$$\begin{aligned}\hat{\pi}_i(\varsigma_t;\theta) &= \hat{u}_{it} + \phi_{it}\hat{d}_{it} \\ &= \tilde{u}_{it} - f_{ss}s_{it} + (\mu v_t + (\kappa v_t)\nu_{it})\hat{d}_{it}.\end{aligned}$$

$\tilde{u}_{it}$ is the estimate of the product market profit of firm i at state ς_t but does not include the fixed costs $f_{ss}s_{it}$, and $\hat{d}_{it}$ is the estimated divestment action, which depends on the estimates of the choice probabilities, $\mathbf{G}(\varsigma_t;\hat{\lambda})$. Note that the unknown parameters (μ, κ) and f_{ss} enter linearly in the per-period cash flow. Therefore, the expected value function of firm i starting from ς can be rewritten as

$$\begin{aligned}\hat{V}_i(\varsigma;\theta) &= \frac{1}{H}\sum_{h=1}^{H}\left[\sum_{t=0}^{\infty}\beta^t\tilde{u}_{it}^h - f_{ss}\sum_{t=0}^{\infty}\beta^t\hat{s}_{it}^h + \mu\sum_{t=0}^{\infty}\beta^t\hat{d}_{it}^h v_t^h + \kappa\sum_{t=0}^{\infty}\hat{d}_{it}^h v_t^h \nu_{it}^h\right] \\ &= \frac{1}{H}\sum_{h=1}^{H}\sum_{t=0}^{\infty}\beta^t\tilde{u}_{it}^h - f_{ss}\frac{1}{H}\sum_{h=1}^{H}\sum_{t=0}^{\infty}\beta^t\hat{s}_{it}^h + \mu\frac{1}{H}\sum_{h=1}^{H}\sum_{t=0}^{\infty}\beta^t\hat{d}_{it}^h v_t^h + \kappa\frac{1}{H}\sum_{h=1}^{H}\sum_{t=0}^{\infty}\hat{d}_{it}^h v_t^h \nu_{it}^h.\end{aligned}$$

By this linearity, the computation of each value function is done only once when searching for the estimates of the parameters (μ, κ, f_{ss}) in the second step.

the parameter values of the sell-off value distribution and fixed costs are set to satisfy equilibrium condition (16) at each state ς.

Let $x \in X$ index the equilibrium conditions, so that each x denotes a particular (i, ς, d_i') combination, and θ be the parameters estimated in this step. The difference between the equilibrium value function for firm i at ς and an alternative value function at this state is defined as follows:

$$g(x; \theta, \hat{\alpha}, \hat{\gamma}, \hat{\lambda}) = \hat{V}_i(\varsigma; \mathbf{d}^*(\varsigma, \phi); \theta, \hat{\alpha}, \hat{\gamma}, \hat{\lambda}) - \hat{V}_i(\varsigma; d_i'(\varsigma, \phi_i), \mathbf{d}^*_{-i}(\varsigma, \phi_{-i}), ; \theta, \hat{\alpha}, \hat{\gamma}, \hat{\lambda}), \quad (23)$$

where $d_i'(\varsigma, \phi_i)$ is an alternative nonequilibrium policy function. These estimated value functions depend on the first-stage estimates, the choice probabilities $G(d_i|\varsigma; \hat{\lambda})$, and the profit function parameters $\hat{\alpha}$ and $\hat{\gamma}$, as well as the parameters of interest in the second step, $\theta = (f_{ss}, \mu, \kappa)$. The equilibrium condition is satisfied at θ if $g(x; \theta, \hat{\alpha}, \hat{\gamma}, \hat{\lambda}) \geq 0$. The goal of the second-step estimation is to find the values of the parameters that best satisfy the entire set of inequalities. However, it is difficult to do this because the entire state space is quite large and there are many alternative policies. Therefore, following BBL (2007), a small subset of the inequalities to impose in the estimation is chosen. Specifically, 600 equilibrium conditions (100 equilibrium conditions per each region) are chosen randomly and, to obtain alternative value functions, the estimated cut-off points are perturbed by adding a random term.[38]

The objective function is defined as follows:

$$Q(\theta, \hat{\alpha}, \hat{\gamma}, \hat{\lambda}) = \frac{1}{N_I} \sum_{j=1}^{N_I} (\min\{g(x_j; \theta, \hat{\alpha}, \hat{\gamma}, \hat{\lambda}), 0\})^2, \quad (24)$$

where N_I is the number of randomly chosen inequalities. The estimator of the struc-

[38]Following Srisuma (2013), the equilibrium cut-off points of all possible actions of firm i at state ς, $\Phi(\mathbf{G}_i(\varsigma))^{-1}$, are transformed to $\Phi(\hat{\mathbf{G}}_i(\varsigma))^{-1} + \xi_i$ by adding sufficiently small ξ_i, which is drawn the normal distribution with a mean zero and a standard deviation of 0.3. Srisuma (2013) show that this way of perturbing cut-off points has an identifying power for θ.

tural parameters is a solution $\hat{\theta}$ to the problem

$$\min_{\theta} Q(\theta, \hat{\alpha}, \hat{\gamma}, \hat{\lambda}). \tag{25}$$

This is a two-step estimator as discussed in Newey and McFadden (1994) and, thus, the variance–covariance matrix of $\hat{\theta}$ is complicated since it depends on the variances of the first-step parameter estimates $\hat{\alpha}$, $\hat{\gamma}$ and $\hat{\lambda}$. Furthermore, as the equilibrium and alternative value functions are approximated by a simulation method, simulation error also affects the variance of the structural parameter estimates $\hat{\theta}$ as discussed in McFadden (1989) and Pakes and Pollard (1989). Accounting for these influences, the estimate of the variance and covariance matrix ς is given by

$$(1 + \tfrac{1}{H})\mathbf{Q}_{\theta\theta}^{-1}\mathbf{Q}_{\theta(\alpha,\gamma,\lambda)}\boldsymbol{\Sigma}_{\alpha\gamma\lambda}\mathbf{Q}'_{\theta(\alpha,\gamma,\lambda)}\mathbf{Q}_{\theta\theta}^{-1}, \tag{26}$$

where H is the number of simulation draws from the standard normal distribution, $\mathbf{Q}_{\theta\theta} \equiv \frac{\partial^2}{\partial\theta\partial\theta}Q(\theta, \hat{\alpha}, \hat{\gamma}, \hat{\lambda})$, $\mathbf{Q}_{\theta(\alpha,\gamma,\lambda)} \equiv \frac{\partial^2}{\partial(\alpha,\gamma,\lambda)\partial\theta}Q(\theta, \hat{\alpha}, \hat{\gamma}, \hat{\lambda})$, and $\boldsymbol{\Sigma}_{\alpha\gamma\lambda}$ represents the variance of the estimates of the parameters in the first step.

7 Estimation Results

Having described the model of service station divestment in a dynamic oligopoly and the estimation procedure using the two-step approach of BBL (2007), the stage is now set to present the results of the estimation.

7.1 Results of the First-step Estimation

Demand Function Table 6 shows the results of the demand function estimation. To control for market-specific effects on quantity, dummy variables for regional markets as well as the amounts of regional construction investment are also included as demand shifters. Demand functions are estimated using both ordinary least squares (OLS) and instrumental variable (IV) regression. In the IV regression, the regional fuel price serves as an instrumental variable. The last column in the table labeled “1st stage” shows the result of the first-stage regression in the IV regression and confirms that the fuel price works well as an IV. The estimated price coefficient has the expected sign, and, as expected, the simultaneity bias arising in the OLS regression appears to be considerably reduced in the IV regression. The estimate of the coefficient for construction investment also has the expected sign and is both statistically and economically significant. In the following estimation and simulation, the estimates from the IV regression are used.

Cost Function The parameter estimates of the cost function are presented in Table 7. Specification (1) only includes region fixed effects, while specification (2) includes firm fixed effects as well as region fixed effects. Meanwhile, specification (3) includes region-firm fixed effects. The coefficient estimates for the number of SSs and the fuel price are essentially the same in specifications (2) and (3). As expected, the more SSs a firm has within a region, the lower is its marginal cost of delivering products, likely because the larger number of SSs allows it to avoid long-haul secondary distribution. The marginal cost also fluctuates with the fuel price, because cement is delivered by truck.

To examine how well the model explains the observed outcomes, the Cournot equilibrium for each region and year is computed using the estimated demand and marginal cost functions, and the model predictions are then compared with the observed quantities.[39] The result is presented in Table 8 and indicates that regardless of the specification of the marginal cost function, the model predicts the observed quantities very well, although in the lower quantiles the predictions are relatively imprecise.

[39]The errors in the demand and marginal cost functions are set to zero in calculating the Cournot equilibrium.

In the analysis that follows, the cost function with region-firm fixed effects will be used, because the correlation coefficient for this specification is higher than that for the specification with region and firm fixed effects.

Policy Functions To obtain the equilibrium policy rule, the probability of each possible action at each state is estimated using an ordered probit model, and the cumulative probabilities are calculated. Then the set of cut-off points for firm i in state ς, $\bar{\mathbf{W}}_{id_i}(\varsigma)$, is calculated by inverting the (standard) normal distribution and evaluating the inverted distribution at $\mathbf{G}_i(\varsigma;\hat{\gamma})$ in the way proposed in the previous section.

In this estimation, firms' actions are explained by the number of SSs firms own, region-firm fixed effects, the number of SSs each competitor has, as well as competitors' region-fixed effects, regional construction investment, and regional GDP, which affects the distribution of sell-off values.[40] In addition, region fixed effects are introduced in order to control for time-invariant unobserved factors that affect the divestment probability. These region fixed effects include payoff-relevant time-invariant state variables, such as region specific time-invariant factors shifting demand, and, if there are different equilibria in different markets, include payoff-irrelevant variables, which affect equilibrium selection. Furthermore, to make the estimation as close as possible to that suggested by BBL (2007), not only region fixed effects but also as many interaction terms between state variables and region dummies as possible are included.

Table 9 presents the parameters estimates of the ordered probit model. The number of own SSs is positively related to divestment in all specifications. The marginal effects

[40]In this estimation, firms' and competitors' fixed effects include the effect of the fuel price, $w_t^{\gamma_2}$. The fuel price could be included as a separate state variable; however, since it is highly correlated with the other variables, the composite variables, which consist of firm fixed effects and the effect of the fuel price, are used.

on divestment probabilities (not shown) range from -0.04 to -0.1.[41] Given that the unconditional rate of divestment is around 25%, the impact is economically substantial. The firm fixed effect, Own FE, is positively related to divestment in specifications (2) and (3), as expected, while it is negatively related to divestment in specification (1). The marginal effect of Own FE on the probability of divestment (not shown) is about -.0001 in specification (1) and less than .0001 in specifications (2) and (3). This means that, according to specifications (2) and (3), a one standard deviation increase in Own FE, that is around 1,000 (yen), increases the divestment probability by about 0.07-0.1. Thus, although in the estimation here the (marginal) effect of firm-specific fixed effects is not statistically significant because it is highly correlated with the number of firms' own SSs (and competitors' fixed effects), the result suggests that the marginal effect may potentially be substantial.

Next, as expected, the number of competitors' SSs is positively related to divestment probabilities. The more SSs competitors have, the less demand a firm is likely to face, and the more likely it is to divest its SSs. The marginal effects of the most efficient competitor on divestment probabilities range from 0.02 to 0.03. Although the effects of the second, third, and forth competitors' SSs seem to be not statistically significant independently, the likelihood ratio (LR) test, which compares specification (1) with the restricted model (5) where the second, third, and fourth competitors' SSs are excluded, reject the hypothesis that all of the second, third, and fourth competitors' coefficients are zero at the 10% significance level (the LR test statistic: 7.49).

In specification (4), competitors' FEs are included as well as competitors' SSs. Some of the coefficients for competitors' FEs have a positive sign, which is the opposite of

[41]The marginal effects are evaluated at the mean and are the sum of the marginal effects on non-zero divestment probabilities.

what one would expect.[42] The likely reason for this unexpected result is the high correlation among competitors' fixed effects. The smallest correlation coefficient is about 0.92, meaning that it is difficult to distinguish the effect of each variable on the divestment probability. Further, compared with specification (1), the log-likelihood ratio test statistic is 1.82 and the likelihood ratio test fails to reject the hypothesis that all of the coefficients on competitors' fixed effects are zero. The reason for this result is the way that the explanatory variables is constructed: the order of competitors' SSs is determined by competitors' cost efficiencies and, thus, part of the impacts of firm-specific efficiencies on the divestment probability is already captured. For the above reasons, specifications without competitors' FEs are used in the following analysis.

Next, looking at the two exogenous variables, their impact on the divestment probability is as expected. The amount of regional construction investment has a negative effect on the divestment probability. The effect is statistically significant and in fact quite large, with the marginal effect ranging from 0.0001 to 0.0006. Concretely, based on specification (1), this means that a one standard deviation decrease in regional construction investment leads to a 0.45 point increase in the divestment probability. The effect of regional GDP has the expected sign and is also substantial, although its p-value is just above 0.1 in all specifications due to the high correlation with regional construction investment (correlation coefficient: 0.94).

To check the accuracy of the estimated policy rule, the divestment probabilities predicted by the model are compared with the observed actions. Table 10 shows the observed distribution of divestments during the observation period and that of predicted divestments. The policy function works very well: regardless of the specification, the

[42] These positive effects are counterintuitive, since more efficient competitors will take demand from a firm, so that it is more likely to be forced to divest. However, the sum of the estimated coefficients is always negative, and the value of the vector of coefficient estimates multiplied by the vector of competitors' FEs is also always negative, so that the results overall are in line with expectations.

predicted distributions are almost identical to the actual divestment distribution.

As an additional check, the predicted number of divestments in each year is compared with the actual number of divestments. This comparison examines how well the model captures the course of observed divestment behavior. Table 11 provides the actual and predicted number of divestments in each year. The period 1998-2009 saw two phases during which divestment accelerated: the period 1998-1999 and the period 2002-2005. All specifications capture the first wave well. On the other hand, the predictions for the second period are too low in all specifications. Moreover, as a result of this underprediction, the predictions for the number of divestments before this period are too high.

However, like the actual data, the predictions have two peaks and closely trace the observed course of divestment, although they smooth out some of the smaller peaks and troughs. Taking into account that a flexible nonparametric estimation is not feasible here due to data limitations and that a parametric model inevitably smoothes fluctuations in the data, the estimated policy function works sufficiently well for the purposes here.

For the following second-step estimation, specification (1) is used for the benchmark and specification (3) is used as an alternative specification.

7.2 Result of the Second-step Estimation

The second step of the estimation consists of searching for the values of the parameters (μ, κ, f_{ss}) that best satisfy the equilibrium conditions, which are defined as the distance between the equilibrium value function and a randomly chosen alternative value function. Parameter estimates of fixed costs and the sell-off value distribution are presented in Table 12. As explained in Section 6, three alternatives for the lower bound of construction investment are used for estimating the parameters. The row labeled

"Demand" indicates these alternative lower bounds–"Optimistic," "intermediate," and "Pessimistic"–used for this estimation. The last row, "Policy Func.," indicates the policy function specification used for the estimation, with the numbers, (1) and (3), corresponding to the specifications in Table 9.[43]

The fixed cost estimates vary, depending on the demand and policy function specification, while the parameter estimates of the sell-off distribution are relatively similar to each other regardless of the specification. The estimated fixed costs are about 29-80 million yen. This amount is not negligible, since it represents about 3-10% of the firms' total costs and thus has a substantial impact on their profits. The estimated sell-off value distribution is very narrow in all specifications.

8 Counterfactual Simulation

Having estimated the structural parameters governing the dynamics of the Japanese cement industry, the stage is now set to conduct a simulation exercise in order to examine the main issue of interest of this study, namely the welfare impact of the mergers seen in the Japanese cement industry.

This experimental exercise considers a counterfactual in which no mergers take place. For the counterfactual, all of the merged firms are split into the original independent firms again: Sumitomo-Osaka Cement is split into Osaka Cement and Sumitomo Cement, Taiheiyo Cement is split into Chichibu Cement, Onoda Cement, and Nihon Cement, and Ube-Mitsubishi Cement is split into Mitsubishi Cement and Ube Cement. Table 13 presents the setup of the counterfactual. Specifically, the table shows, for each region, the number of service stations of each cement firm in the actual (" With Mergers") and the counterfactual ("Without Mergers"). The Firm ID identifies the different

[43]The same draws of sell-off values are used for simulating value functions (equation (22)) under different policy function specifications and different demand bounds.

firms. SO stands for Sumitomo-Osaka, which in the counterfactual is divided into two firms, SO1 standing for Osaka and SO2 for Sumitomo. The same applies to the other merged firms, with THY standing for Taiheiyo, which in the counterfactual is spilt into THY1 standing for Chichibu, THY2 for Nihon, and THY3 for Onoda, and UM standing for Ube-Mitsubishi, which is split into UM1 standing for Mitsubishi and UM2 for Ube. The other Firm IDs, AS, DK, NT, and TK, stand for Aso, Denka, Nittetsu, and Tokuyama, respectively.

To conduct the simulation exercise, information on region-firm fixed effects for both merged and independent firms is necessary.[44] In order to obtain region-firm fixed effects, the marginal cost function defined in the section 6 is estimated using observations not only for the period 1998-2009 but also the period 1991-1993. The reason for including the period before the mergers examined here took place is that the firm-specific effects of the pre-merger firms are also necessary for the counterfactual simulation and thus need to be estimated. The details of the estimation procedure and a discussion of potential problems arising are provided in Appendix A. The row labeled "γ_{0ri}" in Table 13 presents region-firm fixed effects (in log terms). As can be seen in the table, the region-firm fixed effect, which represents a firm's efficiency, increased (on average) for all firms following a merger, except firm SO in region 1 and region 4.[45]

The simulation exercise for each regional market should reflect the real-world environment as much as possible. However, the computational burden involved in solving

[44] As discussed in 5.7, the reason for including region-firm fixed effects is that not including firm-specific cost effects potentially causes a serious problem in the simulation exercise. For instance, suppose that firms which merged were relatively inefficient before they merged. In this case, these firms would have divested their SSs even if they had not merged. This implies that the effect of mergers on divestment would be overstated. To avoid this type of problem, region-firm fixed effects are introduced in this study. The referees' comments on this issue were very helpful.

[45] Sumitomo Osaka is a merged firm. Before the merger, only one of Osaka (SO1) and Sumitomo (SO2) operated in regions 1, 2, and 5, so they could not merge their operations in these regions. Nevertheless, it is possible that the merger may have influenced the efficiency of Sumitomo Osaka operations in these regions through the unification and reorganization of the nationwide distribution network, thus affecting transportation costs in primary delivery from cement plants to service stations.

for an MPE would be severe, meaning that conducting such a complete experiment is difficult. For example, in the largest market, there are nine firms in the counterfactual environment and the total number of SSs amounts to 67. This means that the total number of firms' states amounts to 6,879,600, and this number is then further multiplied by the number of states of the three exogenous variables. While solving a dynamic game with such a large number of states is not impossible, it is extremely computationally burdensome. Because of this computational constraint, the approach taken here is to approximate each regional market by a smaller version of it. To create such hypothetical markets, first, the number of SSs in each region is reduced by either about 20% or 30%, depending on the total number of firms' states in the region. For regions 1, 2, 4, and 6, the total number of SSs (observed in 1993) is reduced by about 20%, while for regions 3 and 5 the number of SSs is reduced by about 30%. Second, the values of two of the three exogenous variables, namely of, regional GDP and the fuel price, are fixed. The reason for doing so is that the main focus of this study is the relationship between mergers and divestment, and these two variables are only of tangential interest. Finally, the maximum number of divestments is restricted to one.[46]

A very useful algorithm for computing equilibria of stochastic dynamic games is the one developed by Pakes and McGuire (1994), which has become a widely used tool for applied research in the field.[47] Although their algorithm could be applied here, to alleviate the computational burden an alternative way of computing an MPE using

[46]This restriction may influence the simulation results as it slows down the potential speed of adjustment in the industry. Specifically, if in practice merged firms divested more SSs in an actual environment than in the simulation, the difference between the number of merged firms' SSs and independent firms' SSs in the early period of the simulation would likely be smaller in this setting than in a setting where more than two divestments are allowed. This means that the effect of mergers on the total amount of fixed cost savings would be underestimated.

[47]Pakes and McGuire (2001) proposed a stochastic algorithm to break the "curse of dimensionality" in solving for the equilibria of a recurrent class model. Although their algorithm can deal with a large number of firms, the model considered in this study does not belong to this class.

the unique structure of the model considered here is employed.[48] In this model, the movements of the endogenous state variables are weakly unidirectional. The number of a firm's SSs only goes down, and once these state variables reach the terminal state, this state lasts forever. Calculating the value functions in the terminal state is straightforward, because they are just the sum of future cash flows at the state, and the remaining states can then be solved by a backward induction procedure.[49]

Once the model is solved for both market structures, it is possible to obtain simulation paths and compare outcomes in order to evaluate the effect of the mergers on total welfare. The starting states in the two market structures are shown in Table 13. Regional market structures without mergers are set by reducing the number of SSs using the manipulation explained above and then allocating them to firms based on their share of SSs observed in 1993. Next, to create market structures with mergers, firms which were involved in a merger are merged. Actual regional construction investments in each region in 1993 is used as the starting demand level z, and the means of regional GDPs and fuel prices are used for these variables.

The results of the simulation are shown in Table 14. One thousand sample paths with a length of 15 years for each market are generated, and the sample average of these paths is reported. "CS" in the table is the change in the consumer surplus as a result of the mergers, which is based on equation (6), while "PS" is the change in the producer surplus, which is based on equation (5) but does not include fixed costs

[48]In this simulation exercise, two sample equilibria are computed by this algorithm. Since this model does not satisfy one of the sufficient conditions for the uniqueness of equilibria, there is the possibility that multiple equilibria arise. Specifically, in the model, movements through the state space are unidirectional while the reaction functions may not necessarily intersect only once. Therefore, the presence of multiple equilibria cannot be ruled out. A possible remedy is to start the algorithm from various starting values, and that is what is done here. Several initial divestment probabilities, 0.1, 0.25, 0.5, 0.75, and 0.9, are tried, and, for these initial values, no multiple equilibria is found.

[49]This solution algorithm is very similar to that provided by Judd, Schmedders, and Yeltekin (2006). They consider a patent race where the state variables only go up to the higher states.

and scrap values. "FC" indicates the change in the sum of the fixed costs incurred, while "SV" is the change in the sum of sell-off values. "Total" is the sum of changes in the consumer surplus, the producer surplus, the fixed costs, and the sell-off values. Finally, "Demand" shows the lower bound of the decline in demand under which the parameters estimates are obtained.

The results for the 15-year simulation suggest that the mergers increased total welfare in all regions. The welfare gain as a result of the mergers ranges from 13.61 billion yen (in region 4) to 115.38 billion yen (in region 6), depending on the market size and the assumptions regarding the decline in demand. Relative to the total welfare level in the counterfactual market structures, the mergers improved total welfare by 2.48% to 9.3%.

Generally speaking, the overwhelming part of the positive welfare effect stems from the increase in the producer surplus. The only region in which the consumer surplus also makes a positive contribution is region 2.[50] An increase in the number of SSs that a firm has as a result of a merger allows the firm to allocate supply to service stations close to its customers, thus avoiding costly long-haul delivery, providing merged firms with a cost efficiency gain. This efficiency gain coupled with improvements in firms' fixed effects is sufficiently large to outweigh the loss in the consumer surplus observed in all regions except 2. This effect is what is considered as the synergy effect of mergers.

Next, let us examine the contribution of changes in fixed costs and sell-off values, "FC" and "SV," in Table 14. The results indicate that in markets with mergers, firms, as a consequence of SSs being scrapped, generally achieved greater fixed cost savings and generated more income from sell-offs than in the counterfactual markets with no

[50] An improvement in both the consumer and the producer surplus can occur when there are large synergy effects with regards to marginal costs. In practice, the (average) improvements in region-firm fixed effects in region 2 is -0.12, which is higher than in any of the other regions, where it is -0.05 (region 1), -0.04 (region 3), -0.02 (region 4), -0.10 (region 5), and -0.10 (region 6).

mergers. The only exceptions are region 2 and region 4 in specifications b2 and c2.[51] These two effects improved producers' welfare additionally.[52] Such fixed cost savings and changes in sell-off values represent a substantial part of the welfare gain in some regions. For instance, in region 1, the sum of fixed cost savings in the 15 years accounts for 1-9% of the total welfare improvement and the contribution of fixed cost savings and changes in sell-off values amounts to 12-26% of the total welfare gain. And in region 3, the contribution of fixed cost savings and changes in sell-off values amounts to 9-23% of the total welfare gain. This result highlights that, as already pointed out by Berry and Pakes (1993), it is importance to take the effects of outcomes arising from the dynamic decision process on total welfare into account when examining the impact of mergers.

The question that naturally arises is why more SSs are scrapped in markets with mergers. As pointed out by Ghemawat and Nalebuff (1990), divestment, such as scrapping an SS in this study, can be regarded as a public good that must be provided privately. The reason is that the increase in price from the reduction in SSs benefits all firms, so that they have an incentive for free-riding on someone else's divestment. Merged firms can partly internalize this spillover effect of divestment and are therefore more likely to divest. Consider the case where a firm, A, merges with one of its competitors, B. Suppose that after the merger, the merged firm scraps one of its SSs and the equilibrium price rises as a result. In this case, the benefit of the higher price

[51]In region 2, there are large synergy effects in region-firm fixed effects. This is one of the main reasons why only in this region fewer SSs are scrapped in the scenario with mergers than in the counterfactual scenario without mergers. On the other hand, when the length of simulation is extended to 20 (25) years, the difference in the sum of fixed cost savings is overturned in region 4 in specification b2 (c2). A possible reason is that in this simulation exercise the number of divestments in each period is restricted to one and this restriction slows down the speed of adjustment.

[52]The estimate here presents the upper bound of the total welfare effect of the mergers because the sell-off values themselves are net gains to firms in the industry but not net gains to society. However, even if the sell-off values are excluded from the total welfare calculation, the fixed costs savings still account for a non-negligible part of the total welfare gain.

enjoyed by firm B (A) is completely realized in terms of firm A (B)'s own profit. The merged firm can partly internalize the business-stealing effect and, consequently, has a stronger incentive for divestment than does a non-merged firm.[53]

In oligopolies, there is a tendency for capital investment to be greater than the industry as a whole would want, as shown by Okuno-Fujiwara and Suzumura (1993).[54] This means that there is a tendency for the total number of SSs to be excessive. In such a situation, a reduction in the number of SSs (and that of firms) can be beneficial at least for firms in the industry and possibly from a total welfare perspective. The simulation results presented in Table 14 show that the mergers generally promoted divestment through the internalization effect explained above (although there are a few exceptions) and increased producers' profits through fixed costs savings, and improved total welfare since the positive effect for firms is larger than the negative effect for consumers.[55]

One interesting point that should be mentioned is the following: not only is the total sum of changes in the consumer surplus and the producer surplus, which does not include fixed costs savings and sell-off values, positive but the per-period welfare

[53]Note that in general, a merger raises the equilibrium price and profits. Therefore, higher profits have the opposite effect on the incentive for divestment. The simulation result indicates that the internalization effect outweighs this profit effect and mergers consequently promote the scrapping of SSs in regions 1, 3, 5 and 6 (in all specifications) and in region 4 except specifications b2 and c2.

[54]In a setting with constant marginal cost and constant-elasticity demand functions, they show that in symmetric oligopolies, the amount of (continuous) investment improving marginal cost, such as R&D investment, becomes excessive not only for producers but also for society. They also show that even in duopolies the amount of investment is socially excessive in the case of linear demand functions. The model here shares some of the assumptions of their model. The inverse demand function employed here falls within the class of constant elasticity demand functions, and firms' marginal cost functions are constant regardless of the quantity supplied. Further, the number of SSs plays the same role as R&D investment in their model.

[55]As seen in region 2 and region 4 in specifications b2 and c2, it is possible that the sum of sell-off values in the actual environment is higher than that in the counterfactual even if the number of SSs scrapped is smaller in the actual environment. The reason is that, in these regions, in order to scrap a SS, firms in the actual environment require higher sell-off values than firms in the counterfactual. Therefore, even if the number of divestments is smaller, the sum of sell-off values in the actual environment can be greater than that in the counterfactual.

gains, "CS+PS," are also still positive 15 years after the mergers, as shown in Table 15 (and the per-period gain in every year in every region is positive). This is a little bit surprising given that firms in markets with mergers scrapped more SSs than firms in markets with no mergers and this divestment affected firms' marginal cost negatively. These divestment dynamics must have negatively affected both the producer and the consumer surplus. Nevertheless, the CS+PS is still positive even in the 15th year after the mergers (although the gains become smaller).

To understand this, theories on merger profitability may provide a clue. In the context of endogenous mergers, Fauli-Oller (2000) and Qiu and Zhou (2007) show that negative demand shocks are favorable to merger profitability and are one of the key driving forces triggering mergers. The reason is that a negative demand shock dampens rival (non-merged) firms' output increases in response to a merger. As a result, the cost improvement required for making a merger profitable is smaller than in an environment without a negative shock. This theoretical result implies that as demand declines, merger profitability increases, and a merger can be more favorable (at least) to the merged parties. In the case examined here, this effect of a negative demand shock on the per-period change in the producer surplus partly offsets the negative effect of merger-induced divestment, which is also induced by the negative demand shock, on the producer surplus, so that the per-period welfare gains, "CS+PS," are still positive.

Finally, it is worth comparing the long-run and the short-run results. At the time of the mergers, that is, in the short-run, where there are no capital adjustments, total welfare increases. Moreover, the increase in total welfare persists in the long-run. Therefore, the static and dynamic analyses of the welfare effect of the mergers lead to the same conclusion, namely, that the mergers increased total welfare.[56] However,

[56]In this sense, the results obtained here are not as surprising as those obtained by Berry and Pakes (1993), who find that both the producer and the consumer surplus fall at the time of the merger and

the dynamic empirical model employed in this study provided important additional insights in that it showed that the fixed costs savings and changes in scrap values account for a non-negligible part of the total welfare gain. Ignoring the consequences of the capital adjustment in the long-run leads to a serious miscalculation of the total welfare effect of the mergers.

9 Conclusion

In oligopolistic industries, the presence of a business-stealing effect and fixed costs creates a wedge between the capital stock that is optimal for individual firms and the capital stock optimal for the industry as a whole. In the case of declining industries, the amount of capital divestment is likely to be less than what would maximize the industry's total profit. Although removing excess capital stock would lead to an increase in total industry profit, such divestment is not undertaken voluntarily because once a firm removes its capital stock, part of its business will be captured by its rivals. Thus, regardless of the decline in demand in such an industry, the situation of excess capital will persist.

Mergers are expected to solve this situation. Merged firms can internalize the business-stealing effect and promote the reduction in capital stock. However, mergers involves a trade-off: mergers may increase market power and are harmful to consumer while they may also create efficiency gains. Therefore, mergers in declining industries consequently are not necessarily beneficial for society as a whole.

Against this background, this study focused on the role of mergers as a means to promote divestment and examined whether merger-induced divestments could increase not only producer profits but also total welfare. To analyze mergers in an environment

that, as time passes, the merger increases total welfare by reducing investment costs.

where the industry's amount of capital constantly changes and the demand level shifts down over time, the study used the Markov-perfect equilibrium framework of Ericson and Pakes (1995) to describe the dynamic divestment decision process. The simulation exercise showed that merged firms had more incentive to scrap their distribution centers and that such divestments as a result of mergers could lead to the improvement of welfare. In particular, savings on fixed costs (as well as the realization of the sell-off value of divested assets) made a non-negligible contribution to the improvement in welfare.

In addition to the academic interest, this study also has an important policy implication. US horizontal merger guidelines states that "the agencies consider merger-specific, cognizable reductions in fixed costs, even if they cannot be expected to result in direct short-term, procompetitive price effects because consumers may benefit from them over the longer term even if not immediately".[57] The results of this study showed that horizontal mergers facilitated divestment and thereby reduced fixed costs. They also showed that this fixed cost savings was a substantial contribution to total surplus. According to the US guidelines, such mergers will not be accepted because, even in long run, price reduction is not expected to take place. However, if the total surplus is to be the welfare criterion, the mergers possibly had better be accepted. This study, therefore, will provide a critical policy question to the competition policy authority.

Finally, possible extensions as well as some shortcomings of this study should be noted. While the analysis here focused on the after-merger behavior, a more realistic approach would incorporate endogenous merger decision processes into the empirical model to investigate the merger incentive itself. Studies by Gowrisankaran (1999), Fauli-Oller (2000), Pesendorfer (2005), Toxvaerd (2007) and Qiu and Zhou (2007)

[57] US department of Justice and Federal Trade Commission, "Commentary on the Horizontal Merger Guidelines,", March 2006, p.58.

provide the theoretical framework that could make this possible.[58] Furthermore, this study analyzed only the unilateral effect of horizontal mergers. The reduction in the number of incumbents may increase the possibility of collusive conduct within a market. In almost all cases, collusion raises prices and thus is detrimental to consumers, lowering the consumer surplus further. Therefore, such collusive conduct has important welfare implications and the results obtained in this study might be overturned. Modeling collusion in a dynamic world is one of the open research questions in the field of industrial organization. A final point is that the present study treated each region as an independent market and assumed that cement firms decided their divestment strategies without consideration of the effect of divestment on other markets, even if cement firms operated across several regions. If markets exists are interrelated each other, the divestment decision problem will be more complicated than the simplified description in this study. Jia (2008) relaxes this assumption of independence in a static oligopoly setting. Although it is challenging, developing a model allowing interdependence across markets in a dynamic game would help to further improve the present study by making it more closely reflect reality.

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Figure 1: Cement Consumption and Construction Investment (billion yen)

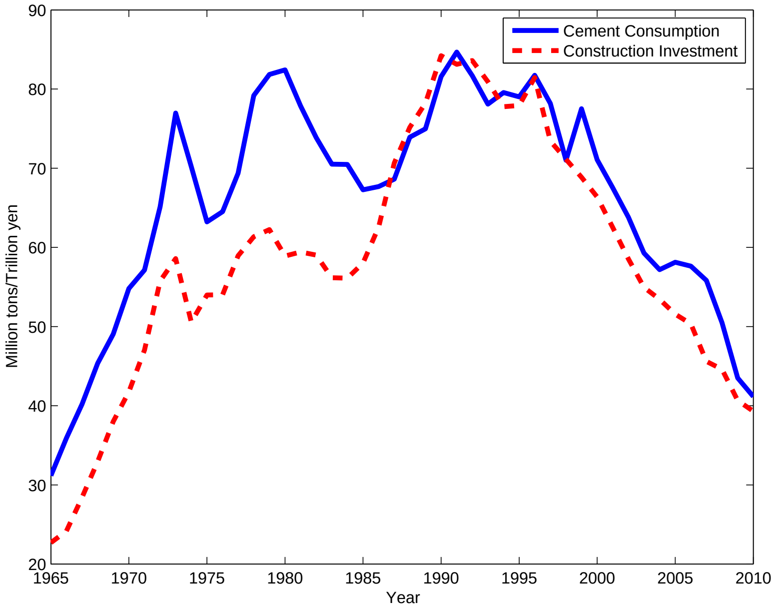

Table 1: Trends in the Number of Cement Distribution Centers and Price (yen)
The column labeled “Total” shows the total number of cement distribution centers (“service stations” or “SS” for short), “M-Firms” is the total number of SSs owned by merged firms, and “NM-Firm” is the total number of SSs owned by non-merged firms. Price is the average price of regional cement prices.

Year	No. SS			Price
	Total	M-Firms	NM-Firms	
1991	591			10,007
1992	595			10,146
1993	594			10,026
1994	584			9,698
1995	577			9,361
1996	564			9,096
1997	559			8,830
1998	531	404	127	8,745
1999	512	387	125	8,772
2000	507	382	125	8,860
2001	501	377	124	8,833
2002	497	375	122	8,857
2003	469	350	119	8,789
2004	445	330	115	8,624
2005	427	314	113	8,574
2006	414	305	109	8,524
2007	408	299	109	8,536
2008	397	292	105	8,577
2009	383	279	104	8,466

Table 2: List of Mergers in the 1990s

Year	Name of Firms Involved in Merger		Name of Merged Firm
1991	Mitsubishi Cement Corp.	Tohoku-Kaihatsu Corp.	Mitsubishi Cement Corp.
1994	Onoda Cement Corp.	Chichibu Cement Corp.	Chichibu-Onoda Cement Corp.
1994	Sumitomo Cement Corp.	Osaka Cement Corp.	Sumitomo Osaka Cement Corp.
1998	Chichibu-Onoda Cement Corp.	Nihon Cement Corp.	Taiheiyo Cement Corp.
1998	Mitsubishi Cement Corp.	Ube Cement Corp.	Ube-Mitsubishi Cement Corp.

Table 3: Number of Firms per Region Before and After the Mergers of the 1990s

Number of firms	Mean	Std. Dev.	Min.	Max.
Before mergers (1993)	9.12	1.66	7	12
After mergers (1998)	5.95	1.21	4	8

Table 4: Three-Firm Concentration Ratio
The concentration ratio is measured in terms of the number of service stations in each regional market.

	Mean	Std. Dev.	Min.	Max.
Before mergers				
1993	0.5642	0.1185	0.4410	0.7931
After mergers				
1994	0.6312	0.1103	0.4950	0.7929
1998	0.8439	0.0918	0.7156	0.9539

Table 5: Summary Statistics
"Cement Price" and "Fuel Price" are in terms of yen, while "Construction Inv." and "Regional GDP" are in terms of billion yen. "Consumption" and "Supply" are in terms of 1,000 tons.

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
Cement Price	72	9279.20	808.20	7878.35	11538.50
Consumption	72	5128.46	2352.26	1687.07	10538.91
Construction Inv.	72	4924.57	2340.30	1395.28	9405.41
Regional GDP	72	43759.72	25474.77	14100	88900
Fuel Price	72	122.71	23.41	90.29	173.62
Supply	360	1002.10	812.17	40.59	3447.86
No. SS	360	8.45	5.38	1	26
Divestment	360	0.275	0.675	4	0

Table 6: Estimates of Demand Function Parameters
"Cement Price" is the logarithm of the annual average price of cement in a region. "Const. Inv." is the logarithm of regional private and government construction investments. Chugoku, Hokkaido, Kinki, Shikoku, Tohoku and Tokai are market fixed effects. "Fuel Price" is the logarithm of the annual average gas price in a region and serves as an instrumental variable. Column (1) shows the result of OLS regression, while the first column under (2) presents the result of the IV regression and the second column shows the result of the 1st stage regression. Standard errors are presented in parentheses.

	(1)	(2)	
	OLS	IV	
			(1st stage)
Cement Price	-0.710	-1.223	
	(0.116)	(0.132)	
Fuel Price			0.262
			0.056
Const. Inv.	0.995	0.879	0.178
	(0.051)	(0.058)	(0.052)
Chugoku	6.681	13.170	5.253
	(1.323)	(1.826)	(0.971)
Hokkaido	6.420	12.863	5.210
	(1.311)	(1.813)	(0.965)
Kinki	6.526	13.060	4.995
	(1.342)	(1.853)	(1.013)
Shikoku	6.900	13.321	5.364
	(1.300)	(1.797)	(0.938)
Tokoku	6.522	13.064	5.223
	(1.338)	(1.845)	(0.986)
Tokai	6.476	12.993	5.019
	(1.338)	(1.848)	(1.004)
R^2	0.988	n.a.	0.424
Observations		72	

Table 7: Estimates of Cost Function Parameters

"NO. SS" is the number of firms' SSs in a region (in logarithm), while "Fuel Price" is the logarithm of the average fuel price in a region. Standard errors are presented in parentheses.

	(1) R-FE	(2) F-FE	(3) RF-FE
NO. SS	-0.145	-0.108	-0.115
	(0.005)	(0.008)	(0.037)
Gas Price	0.104	0.120	0.117
	(0.021)	(0.019)	(0.020)
Region Fixed Effects?	Yes	Yes	No
Firm Fixed Effects?	No	Yes	No
Region-Firm Fixed Effects?	No	No	Yes
R2	0.732	0.774	0.830
Observations		360	

Table 8: Cournot Model Quantity Prediction

The predicted quantity is computed using the estimated parameters of the demand and cost functions. Column (1) presents the observed quantities in each percentiles from the 10^{th} percentile to the 90^{th} percentile and the mean and standard deviations. Columns (2) and (3) also provide the predicted quantities and the mean and standard deviations. The column labeled "F-FE" shows the marginal cost function with region and firms fixed effects and the column labeled "RF-FE" shows that with region-firm effects.

	(1)	(2)	(3)
	Data	Predictions	
Cost function		F-FE	RF-FE
%			
10	292.2	322.8	328.4
20	445.4	564.2	580.8
30	611.2	668.2	742.4
40	727.2	840.5	922.9
50	949.0	1040.1	1037.9
60	1228.6	1300.1	1242.1
70	1613.1	1623.9	1573.4
80	1976.2	2097.6	2054.2
90	2345.0	2364.1	2357.8
Mean	1175.7	1247.3	1247.4
Std. Dev.	801.6	773.4	776.4
		Correlations	
	(1) v. (2)	(1) v. (3)	(2) v. (3)
	0.953	0.977	0.980

Table 9: Divestment Policy Function

"Own NO. SS" is the number of firms' own SSs. "Own FE" is firms' fixed effect, which is a composite term of firms' fixed effect and the effect of the fuel price. Competitors are ordered based on their region-firm fixed effects. Competitor 1 is the most efficient competitor, while competitor 4 is the least efficient competitor. "Const. Inv." is the sum of private and government construction investment in a region. "Own NO. SS × Region r" and "Const. Inv. × Region r" (r = 2, 3, 4, 5, 6) are interaction terms.

	(1)		(2)		(3)		(4)		(5)	
	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.
Own NO. SS	0.2467	(0.0504)	0.3214	(0.0988)	0.4080	(0.1138)	0.2495	(0.0528)	0.1723	(0.0321)
Own NO. SS × Region 2			0.0160	(0.1371)	-0.0896	(0.1553)				
Own NO. SS × Region 3			-0.1610	(0.1409)	-0.1773	(0.1514)				
Own NO. SS × Region 4			-0.0467	(0.1431)	-0.0307	(0.1735)				
Own NO. SS × Region 5			-0.1021	(0.1081)	-0.1523	(0.1236)				
Own NO. SS × Region 6			-0.0724	(0.1229)	-0.1457	(0.1377)				
Own FE	-0.0001	(0.0003)	0.0001	(0.0004)	0.0001	(0.0004)	-0.0001	(0.0004)	0.0000	(0.0002)
Competitor 1's FE							-0.0001	(0.0007)		
Competitor 2's FE							-0.0002	(0.0006)		
Competitor 3's FE							0.0004	(0.0009)		
Competitor 4's FE							-0.0006	(0.0012)		
Competitor 1's NO. SS	0.1101	(0.0423)	0.1104	(0.0473)	0.1405	(0.0588)	0.0995	(0.0486)	0.0587	(0.0272)
Competitor 2's NO. SS	0.0620	(0.0533)	0.0348	(0.0447)	0.1164	(0.0664)	0.0678	(0.0578)		
Competitor 3's NO. SS	0.0077	(0.0656)	-0.0003	(0.0462)	0.0981	(0.0816)	0.0211	(0.0705)		
Competitor 4's NO. SS	0.1137	(0.0685)	0.0624	(0.1094)	0.1140	(0.1139)	0.1015	(0.0817)		
Const. Inv.	-0.0008	(0.0003)	-0.0007	(0.0003)	-0.0014	(0.0007)	-0.0009	(0.0003)	-0.0005	(0.0002)
Const. Inv. × Region 2					0.0014	(0.0008)				
Const. Inv. × Region 3					0.0003	(0.0008)				
Const. Inv. × Region 4					-0.0011	(0.0010)				
Const. Inv. × Region 5					0.0003	(0.0006)				
Const. Inv. × Region 6					0.0009	(0.0009)				
Regional GDP	0.0001	(0.0001)	0.0000	(0.0001)	0.0001	(0.0001)	0.0001	(0.0001)	0.0000	(0.0000)
Region Fixed Effects					Yes					
Loglikelihood	-188.43		-185.42		-180.98		-187.52		-192.17	
Observations					348					

Table 10: Policy Function Prediction: Divestment Distribution

The columns labeled "Predictions" show the estimated average divestment probabilities of all firms except for firms with only one SS. The probabilities in columns (1), (2), and (3) are calculated based on the policy function specifications (1), (2) and (3) in Table 9, respectively.

Divestment	Data	Predictions		
		(1)	(2)	(3)
0	0.817	0.817	0.816	0.815
1	0.122	0.122	0.121	0.122
2	0.036	0.037	0.038	0.038
3	0.019	0.019	0.020	0.020
4	0.006	0.004	0.005	0.005

Table 11: Policy Function Prediction: Trend in Divestment

Columns (1), (2), and (3) show the expected number of divestments. The column numbers correspond to the specifications in Tables 9 and 10.

Year	Data	Predictions		
		(1)	(2)	(3)
1998	16	13.21	14.59	14.08
1999	11	9.61	10.04	9.92
2000	3	7.51	7.68	7.21
2001	2	7.71	8.03	7.93
2002	9	9.81	9.92	10.76
2003	14	10.08	10.07	10.46
2004	12	8.40	7.91	7.93
2005	9	6.18	5.98	5.57
2006	7	7.58	7.53	8.53
2007	3	7.33	7.24	7.39
2008	7	4.48	4.85	4.86
2009	6	5.41	5.53	4.93
Total	99	96.31	97.37	96.57

Table 12: Structural Parameter Estimates (million yen)

Estimates in the first and second columns under (a) are obtained under the most optimistic scenario on the lower bound of the demand level, which is the amount of construction investment in 2009, while estimates in the fifth and sixth columns under (c) are obtained under the most pessimistic scenario. Estimates in the columns under (b) are obtained under the intermediate scenario. The last row, "Policy Func.," indicates the specification of the policy function used. (1) and (3) correspond to the specifications (1) and (3) respectively in Table 9. Standard errors are presented in parentheses.

	(a)		(b)		(c)	
F_{ss}	80486.40	53724.17	69635.81	36774.28	61523.24	29546.40
	(30634.86)	(3961.09)	(38219.77)	(20490.55)	(2794.98)	(11655.18)
μ	28.70	34.44	32.02	38.98	33.85	40.25
	(3.61)	(7.67)	(13.12)	(26.52)	(9.71)	(13.64)
κ	3.73	2.34	3.10	1.71	2.11	1.53
	(0.18)	(0.22)	(0.12)	(0.03)	(0.02)	(0.02)
Demand	Optimistic		Intermediate		Pessimistic	
Policy Func.	(1)	(3)	(1)	(3)	(1)	(3)

Table 13: Simulation Setup

The Firm ID identifies the different firms: SO (in With Mergers) stands for Sumitomo Osaka, while SO1 and SO2 (in Without Merger) stand for Osaka and Sumitomo. THY (in With Mergers) stands for Taiheiyo, while THY1, THY2, and THY3 (in Without Mergers) stand for Chichibu, Nihon, and Onoda, respectively. UM (in With Mergers) stands for Ube-Mitsubishi, while UM1 and UM2 (in Without Mergers) stand for Mitsubishi and Ube. The other Firm IDs, AS, DK, NT, and TK, stand for Aso, Denka, Nittetsu, and Tokuyama. The row labeled "γ_{0ri}" presents region-firm fixed effects (in log terms).

Region 1:Chugoku														
	With Mergers					Without Mergers								
Firm ID	THY	UM	TK	SO	AS	THY3	TK	UM2	UM1	THY2	AS	SO2		
NO.SS	13	12	7	4	4	7	7	6	6	6	4	4		
γ_{0ri}	8.353	8.417	8.484	8.523	8.559	8.370	8.484	8.414	8.512	8.491	8.559	8.513		
Region 2: Hokkaido														
	With Mergers					Without Mergers								
Firm ID	THY	UM	NT	SO	DK	THY2	THY3	NT	UM1	UM2	DK	SO2		
NO.SS	18	6	6	1	1	10	8	6	4	2	1	1		
γ_{0ri}	8.170	8.392	8.303	8.333	8.362	8.210	8.431	8.303	8.524	8.458	8.362	8.422		
Region 3: Kinki														
	With Mergers					Without Mergers								
Firm ID	SO	THY	UM	TK	AS	SO2	SO1	UM1	THY3	UM2	TK	THY2	AS	THY1
NO.SS	16	11	10	4	3	9	7	6	5	5	4	4	3	1
γ_{0ri}	8.368	8.364	8.407	8.423	8.439	8.442	8.420	8.432	8.440	8.441	8.423	8.429	8.439	8.341
Region 4: Shikoku														
	With Mergers					Without Mergers								
Firm ID	THY	UM	TK	SO	AS	TK	THY3	UM1	THY1	UM2	AS	SO2	SO1	
NO.SS	12	11	8	5	4	8	6	6	6	5	4	3	2	
γ_{0ri}	8.425	8.508	8.535	8.433	8.561	8.535	8.503	8.523	8.428	8.499	8.561	8.504	8.400	
Region 5: Tohoku														
	With Mergers					Without Mergers								
Firm ID	THY	UM	SO	DK	NT	UM1	THY3	SO2	THY2	UM2	THY1	DK	NT	
NO.SS	19	15	8	1	1	9	9	8	6	6	4	1	1	
γ_{0ri}	8.387	8.435	8.523	8.565	8.536	8.456	8.439	8.487	8.571	8.624	8.582	8.565	8.536	
Region 6: Tokai														
	With Mergers					Without Mergers								
Firm ID	THY	SO	UM	DK	AS	SO2	THY2	THY3	UM2	THY1	SO1	UM1	DK	AS
NO.SS	17	12	10	2	1	7	6	6	6	5	5	4	2	1
γ_{0ri}	8.230	8.270	8.319	8.378	8.342	8.319	8.393	8.329	8.356	8.446	8.387	8.375	8.378	8.342

Table 14: Welfare Analysis (15 years, billion yen)

(a1)

Demand: Optimistic

$f_{ss} = 80486.40$, $\mu = 28.70$, $\kappa = 3.73$

	CS	PS	FC	SV	CS+PS	Total	% Gain
Region 1	-14.46	33.06	-1.02	1.42	18.60	21.04	2.55
Region 2	13.82	9.27	0.75	0.64	23.09	22.98	3.79
Region 3	-16.38	92.79	-1.09	7.00	76.41	84.50	6.00
Region 4	-13.33	24.62	-1.38	0.94	11.29	13.61	2.48
Region 5	-9.27	49.21	-2.48	6.44	39.94	48.87	4.71
Region 6	-10.25	113.56	-3.27	8.80	103.31	115.38	9.30

(a2)

Demand: Optimistic

$f_{ss} = 53724.17$, $\mu = 34.44$, $\kappa = 2.34$

	CS	PS	FC	SV	CS+PS	Total	% Gain
Region 1	-13.41	32.42	-0.27	2.50	19.01	21.77	2.62
Region 2	14.24	9.32	0.53	0.26	23.56	23.29	3.81
Region 3	-4.55	64.52	-2.15	12.42	59.97	74.53	5.26
Region 4	-13.93	26.17	-0.99	1.96	12.24	15.19	2.74
Region 5	-9.53	47.98	-2.20	9.68	38.45	50.33	4.84
Region 6	-9.70	112.49	-2.23	9.86	102.79	114.88	9.25

(b1)

Demand: Intermediate

$f_{ss} = 69635.81$, $\mu = 32.02$, $\kappa = 3.10$

	CS	PS	FC	SV	CS+PS	Total	% Gain
Region 1	-14.20	29.70	-1.85	3.68	15.50	21.03	2.54
Region 2	13.27	9.15	0.49	0.67	22.42	22.60	3.73
Region 3	-8.52	66.56	-2.92	15.17	58.03	76.13	5.40
Region 4	-13.23	24.86	-1.08	1.00	11.63	13.71	2.48
Region 5	-8.67	48.44	-1.67	5.23	39.77	46.67	4.50
Region 6	-8.28	107.54	-2.63	8.92	99.26	110.81	8.93

(b2)

Demand: Intermediate

$f_{ss} = 36774.28$, $\mu = 38.98$, $\kappa = 1.71$

	CS	PS	FC	SV	CS+PS	Total	% Gain
Region 1	-13.63	31.43	-0.64	4.37	17.80	22.81	2.73
Region 2	14.16	10.26	0.66	0.30	24.42	24.06	3.92
Region 3	-5.55	63.58	-1.41	17.83	58.03	77.27	5.43
Region 4	-12.64	27.24	0.20	1.27	14.60	15.67	2.82
Region 5	-8.81	48.77	-1.03	7.57	39.96	48.56	4.65
Region 6	-8.50	108.90	-1.32	9.61	100.40	111.32	8.91

(c1)

Demand: Pessimistic

$f_{ss} = 61523.24$, $\mu = 33.85$, $\kappa = 2.11$

	CS	PS	F	SV	CS+PS	Total	% Gain
Region 1	-13.43	30.16	-1.15	3.34	16.72	21.22	2.56
Region 2	13.64	8.83	0.37	0.91	22.46	23.01	3.79
Region 3	-6.36	64.99	-2.19	15.21	58.63	76.04	5.36
Region 4	-12.94	25.21	-0.67	1.10	12.27	14.04	2.54
Region 5	-8.78	48.16	-1.65	5.67	39.37	46.70	4.47
Region 6	-7.93	107.48	-2.26	8.78	99.55	110.59	8.88

(c2)

Demand: Pessimistic

$f_{ss} = 29546.40$, $\mu = 40.25$, $\kappa = 1.53$

	CS	PS	F	SV	CS+PS	Total	% Gain
Region 1	-12.82	32.80	-0.02	2.54	19.97	22.53	2.71
Region 2	13.91	10.55	0.60	0.65	24.47	24.52	4.00
Region 3	-5.50	65.90	-0.87	16.10	60.40	77.37	5.42
Region 4	-12.68	28.35	0.38	0.62	15.67	15.90	2.85
Region 5	-8.54	49.04	-0.73	7.30	40.50	48.54	4.63
Region 6	-8.40	108.48	-1.08	10.11	100.08	111.27	8.92

Table 15: Per-period Welfare Analysis

(a1)-(c1) and (a2)-(c2) correspond to the specifications in Table 14.

Region 1							Region 4						
Year		CS	PS	FC	CS+PS	% Gain	Year		CS	PS	FC	CS+PS	% Gain
1st		-1.22	3.15	0.00	1.93	0.87	1st		-0.88	2.22	0.00	1.34	0.89
15th	(a1)	-0.77	1.64	-0.12	0.87	0.55	15th	(a1)	-0.68	1.06	-0.12	0.37	0.41
15th	(b1)	-0.72	1.10	-0.24	0.38	0.27	15th	(b1)	-0.66	1.02	-0.11	0.36	0.41
15th	(c1)	-0.70	1.19	-0.18	0.50	0.35	15th	(c1)	-0.67	1.05	-0.11	0.38	0.43
15th	(a2)	-0.82	1.56	-0.11	0.74	0.47	15th	(a2)	-0.81	1.12	-0.18	0.31	0.34
15th	(b2)	-0.76	1.26	-0.13	0.50	0.35	15th	(b2)	-0.69	1.18	-0.06	0.49	0.55
15th	(c2)	-0.69	1.45	-0.05	0.76	0.53	15th	(c2)	-0.64	1.25	-0.01	0.61	0.67
Region 2							Region 5						
Year		CS	PS	FC	CS+PS	% Gain	Year		CS	PS	FC	CS+PS	% Gain
1st		0.93	0.95	0.00	1.88	1.13	1st		-1.71	6.34	0.00	4.63	1.66
15th	(a1)	0.72	0.43	-0.04	1.15	1.16	15th	(a1)	-0.40	2.12	-0.35	1.72	0.95
15th	(b1)	0.59	0.44	-0.05	1.03	1.15	15th	(b1)	-0.30	1.89	-0.23	1.59	0.97
15th	(c1)	0.63	0.36	-0.06	0.99	1.11	15th	(c1)	-0.34	1.92	-0.22	1.57	0.96
15th	(a2)	0.80	0.41	0.00	1.21	1.22	15th	(a2)	-0.48	2.02	-0.32	1.54	0.84
15th	(b2)	0.73	0.41	0.00	1.14	1.24	15th	(b2)	-0.41	2.01	-0.16	1.60	0.97
15th	(c2)	0.70	0.42	-0.01	1.11	1.23	15th	(c2)	-0.39	2.04	-0.12	1.64	0.99
Region 3							Region 6						
Year		CS	PS	FC	CS+PS	% Gain	Year		CS	PS	FC	CS+PS	% Gain
1st		-0.97	7.38	0.00	6.41	1.75	1st		-0.53	9.25	0.00	8.72	2.73
15th	(a1)	-1.03	4.91	-0.21	3.88	1.36	15th	(a1)	-0.59	6.63	-0.31	6.04	2.24
15th	(b1)	-0.52	2.58	-0.37	2.06	0.79	15th	(b1)	-0.34	5.63	-0.26	5.29	2.15
15th	(c1)	-0.45	2.52	-0.32	2.07	0.78	15th	(c1)	-0.29	5.61	-0.22	5.32	2.15
15th	(a2)	0.05	2.55	-0.22	2.60	0.91	15th	(a2)	-0.52	6.48	-0.22	5.96	2.20
15th	(b2)	-0.32	2.32	-0.20	2.00	0.76	15th	(b2)	-0.38	5.81	-0.13	5.42	2.20
15th	(c2)	-0.37	2.61	-0.14	2.24	0.86	15th	(c2)	-0.34	5.73	-0.11	5.39	2.19

A Estimating the Marginal Cost Function for the Counterfactual Simulation

An important element of the counterfactual simulation exercise is region-firm fixed effects in the marginal cost function. To obtain estimates of region-firm fixed effects of merged firms and pre-merger independent firms, the marginal cost function is estimated using data covering the periods both before and after the mergers studied here. Specifically, data for years before the mergers (1991 to 1993) are added to the data used in Section 6. The reason for adding these years is that region-firm fixed effects of the firms that are subsequently involved in a merger need to be estimated.[59] The marginal cost function is estimated in the same way as in Section 7 except that region-time dummies taking a value of one after 1997 are introduced. The first column in Table 16 presents the results of this regression, and the estimated region-firm fixed effects, which are presented in Table 13, are used in the simulation exercise.

However, this simple way of estimating the marginal cost function and obtaining estimates of region-firm heterogeneities is potentially problematic. In the data set used here, firms that merged "exit" in 1993 (and then reappear as one "new firm" in 1998). Therefore, whether a firm is included in the data set or not after 1997 depends on whether it merged or not. This potentially causes a sample selection bias in the estimation of the marginal cost function. If there are unobserved factors that affect both the marginal cost function and the selection function (i.e., the function deciding

[59]Pesendorfer (2003) conducts a similar estimation for firm fixed effects using observations of firms both before and after a merger and measures the synergy effects of the merger. Alternatively, only the period before the mergers could be used o estimate the region-firm fixed effects. However, there is insufficient within-firm variation in the number of SSs to reliably estimate the marginal cost function. To avoid this problem stemming from little variation in the data, the period covering years before 1991 could be used. However, if those years are added to the dataset, another type of problem emerges: in the late 1980s, firms in the Hokkaido and Chugoku regions formed cartels, so that it would been necessary to explicitly deal with the presence of collusion to derive marginal costs. Therefore, this period for the estimation is not used.

whether a firm merges or not), this will introduce a selection bias in the coefficient estimates for the number of SSs and the fuel price as well as the estimates of region-firm fixed effects.

Therefore, whether sample selection due to unobservable variables arises is crucial for the estimation here. To check for the presence of such selection bias, a type of Hausman test is conducted.[60] Verbeek and Nijman (1992) proposed a simple and useful test for detecting the presence of selection bias which compares fixed or random effects estimators based on an unbalanced full-panel with those based on a balanced sub-panel. Their approach, which they call the quasi-Hausman test, is based on the following reasoning: if sample selection is unrelated to the error term in a regression model, both the estimators based on the unbalanced full-panel and the balanced sub-panel will be consistent. On the other hand, if sample selection is related to the error term, these two estimators would be biased and be different from each other unless they have identical selection bias.[61] The virtue of their test is that one does not need to explicitly model a selection mechanism and this test is very useful for the current study.

Several types of tests following Verbeek and Nijman's are conducted to check for the presence of selection bias. The first test compares estimates obtained using the unbalanced panel (full sample) including both firms involved in and not involved in a merger with estimates using the balanced sub-panel including only firms not involved in a merger. The basic idea underlying this quasi-Hausman test for selection bias is

[60] Another possibility to test for and resolve such selection bias would be to use an alternative approach such as Heckman's two-step estimation procedure: in the first step, the merger probability (a policy function with regard to mergers) is estimated as a function of exogenous variables including instrumental variables and then, in the second step, the marginal cost function is estimated with the inverse Mills ratio. However, in the case considered here, it would be very difficult to obtain a reliable estimate in the first step, because there were only a few mergers in the cement industry.

[61] Verbeek and Nijman (1992) note that this coincidence is very unlikely.

exactly the same as that of Verbeek and Nijman (1992): if region-firm fixed effects (and other observable variables) capture well important unobserved factors leading to mergers, both estimates must be consistent.

Column (1) in Table 16 presents the estimates using the unbalanced panel (full sample), while column (2) presents the estimates using the balanced sub-panel. The test statics are presented in Table 17. The estimation results in columns (1) and (2) indicate that some of the coefficient estimates in the two estimations appear to differ from each other. Specifically, the coefficient estimates for the number of SSs appear to differ. However, the quasi-Hausman test statistic, shown in Table 17, is 3.90 and its critical value at the 5% level is 13.36.[62] Thus, the null hypothesis that the two estimation results are the same cannot be rejected. This suggests that the estimation of the marginal cost function does not suffer from selection bias. However, the test may be unreliable. The main reason is that the coefficient on the number of SSs is not estimated accurately when using the balanced sub-panel with region-firm fixed effect, primarily because there is relatively little variation in the number of SSs of non-merged firms. Thus, in estimating the marginal cost function using the balanced sub-panel, firm-region fixed effects cancel out most of the effect of the number of SSs on marginal costs.

Next, because the quasi-Hausman test does not convincingly rule out the possibility of selection bias, an alternative test based on an estimation using firm and region fixed effects instead of region-firm fixed effects is conducted. This test examines whether firm-level heterogeneity, instead of region-firm heterogeneity, explains unobserved factors relating to mergers. The results are shown in columns (3) and (4) in Table 16. The Hausman test statistic is 19.64 and the critical values are 23.68 at the 5% level and

[62]Estimates of coefficients on the number of SSs and the fuel price as well as six region-year dummies are used for the test. Even if only a subset of parameters is chosen, the null is not rejected.

21.06 at the 10% level.[63] Again the null hypothesis is not rejected. The estimates in columns (3) and (4) are statistically indistinguishable and, more importantly, are very close to each other. The differences in the coefficients on the number of SSs and the fuel price are only marginal (less than 0.01) and even the maximum difference between two estimators is only 0.09. Thus, not only are the differences statistically insignificant, they are also not economically substantial. This implies that if there were unobserved factors resulting in selection bias, they would be sufficiently controlled for by firm fixed effects.

The last two columns in the table, (5) and (6), show the estimation results when omitting region-firm and firm fixed effects. If there were unobserved factors leading firms to merge, the estimates in columns (5) and (6) would be subject to selection bias. In that case, the results of the two estimations would differ from each other (unless they have identical asymptotic bias). The test statistic is shown in the third row in Table 17. As expected, and in contrast to the previous two tests, the null hypothesis is rejected at the 1% significance level.

These results of the quasi-Hausman tests show that there clearly are unobserved factors affecting both firms' marginal cost and merger decision, but these are captured by the firm-level fixed effects. This implies that the introduction of region-firm fixed effects is highly likely to resolve the selection issue, because region-firm fixed effects capture unobserved factors accurately than firm fixed effects. Consequently, in the simulation analysis in Section 8, region-firm fixed effects are used.

Finally, firm-level efficiency gains arising from the mergers are displayed in the Table 18. The firm-level efficiency gain estimates are based on the firm fixed effects estimates obtained by regressing region-firm fixed effects on firm dummies and region

[63]Estimates of coefficients on the number of SSs and the fuel price as well as six region dummies and six region-year dummies are used for the test.

dummies.[64] The table shows that efficiency gains range from 1.2% to 13.6%. All of these gains are statistically significant at (at least) the 10% level except in the case of the Sumitomo Osaka merger.[65] One of the most important reasons for the efficiency gains is the improvement of nationwide distribution networks that the mergers bring about. Mergers typically involved firms with plants in different regions, and the mergers allowed firms to reorganize their distribution networks not only within a particular regional market but also across the whole of Japan. As a result, such firms were able to shorten the distance from cement producing plants to distribution centers, SSs, and hence increase the efficiency of their nationwide distribution networks. This efficiency gain brings about a downward shift in the marginal cost function.

[64] Using the estimates of firm fixed effects yields almost the same results.

[65] If efficiency gains are measured using firm fixed effects from specification (3), the gains are statistically significant in all cases.

Table 16: Marginal Cost Function Estimates
Standard errors are presented in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)
No. SS	-0.094	-0.040	-0.105	-0.101	-0.135	-0.116
	(0.030)	(0.048)	(0.007)	(0.013)	(0.005)	(0.010)
Gas Price	0.149	0.147	0.143	0.134	0.131	0.130
	(0.022)	(0.029)	(0.021)	(0.028)	(0.023)	(0.028)
Region 1			8.395	8.479	8.498	8.504
			(0.106)	(0.138)	(0.111)	(0.141)
Region 2			8.265	8.204	8.345	8.256
			(0.105)	(0.134)	(0.110)	(0.138)
Region 3			8.401	8.446	8.494	8.466
			(0.105)	(0.136)	(0.110)	(0.139)
Region 4			8.390	8.482	8.481	8.508
			(0.105)	(0.137)	(0.111)	(0.140)
Region 5			8.424	8.429	8.520	8.477
			(0.105)	(0.134)	(0.110)	(0.138)
Region 6			8.395	8.377	8.485	8.418
			(0.104)	(0.133)	(0.110)	(0.137)
Region 1 After Merger	0.148	0.157	0.173	0.147	0.139	0.145
	(0.029)	(0.028)	(0.022)	(0.028)	(0.020)	(0.029)
Region 2 After Merger	0.185	0.185	0.145	0.186	0.105	0.186
	(0.029)	(0.027)	(0.022)	(0.028)	(0.020)	(0.029)
Region 3 After Merger	0.087	0.082	0.103	0.089	0.087	0.091
	(0.029)	(0.028)	(0.021)	(0.028)	(0.019)	(0.029)
Region 4 After Merger	0.170	0.174	0.204	0.170	0.184	0.170
	(0.029)	(0.027)	(0.022)	(0.028)	(0.019)	(0.029)
Region 5 After Merger	0.175	0.165	0.172	0.178	0.136	0.181
	(0.030)	(0.029)	(0.022)	(0.028)	(0.019)	(0.029)
Region 5 After Merger	0.036	0.036	0.006	0.037	-0.024	0.038
	(0.029)	(0.027)	(0.021)	(0.028)	(0.018)	(0.029)
Firm Fixed Effects?	No	No	Yes	Yes	No	No
Region-Firm Fixed Effects?	Yes	Yes	No	No	No	No
R^2	0.842	0.800	0.760	0.793	0.719	0.773
Observations	504	180	504	180	504	180

Table 17: Quasi-Hausman Test for Selection Bias

	Degrees of Freedom	(Quasi) Hausman Statistic
(1) v. (2)	8	3.90
(3) v. (4)	14	19.64
(5) v. (6)	14	35.63

Table 18: Efficiency Gain in Fixed Effect

Firm Name		Efficiency Gain	
Pre-merger	Post-merger	Mean	S.E.
Osaka	Sumitomo Osaka	0.012	(0.041)
Sumitomo	Sumitomo Osaka	0.039	(0.033)
Chichibu	Taiheiyo	0.136	(0.041)
Nihon	Taiheiyo	0.092	(0.033)
Onoda	Taiheiyo	0.090	(0.033)
Mitsubishi	Ube-Mitsubishi	0.064	(0.033)
Ube	Ube-Mitsubishi	0.060	(0.033)

B Modeling Issues: Examining the Effects of Not Endogenizing Mergers (This appendix is not for publication)

In the theoretical model, firms do not consider the possibility of mergers in making their divestment decisions: the probability (firms' expectation) of mergers is assumed to be zero in every state. In fact, there have not been any further mergers since the four mergers considered in this study. However, this does not necessarily mean that firms expected no more mergers to take place during the period 1998-2009, nor does it mean that one can safely assume that firms did not consider the possibility of mergers in making their divestment decisions. Therefore, even though the model used here aims to capture firms' divestment behavior in the post-merger environment in which no mergers took place, there is a potential discrepancy between firms' divestment behavior described in the model and their actual behavior.[66]

This means that whether the model constructed accurately describes divestment behavior in the cement industry depends on (a) whether firms had expected (further) mergers to take place when they made divestment decisions, and (b), if the expected probability of further mergers was not negligible, whether the potential impact of such mergers on the industry was expected to be negligibly small.

To examine these issues, the Herfindahl-Hirschman Index (HHI) provides a clue. Table 19 presents the nationwide supply share of each cement firm and the HHI in 1998 and 2009, while Table 20 presents the region-level share of each firm and the

[66]If an endogenous merger model was constructed and estimated using the sample including pre- and post-merger periods, the probabilities of further mergers (not observed in the real world) could be assigned to each state. More concretely, a merger policy function consisting of firm characteristics such as plants' location and plant size and productivity, and a bundle of region-firm characteristics such as firms' SSs and (region-) firm fixed effect in the marginal cost function could be constructed and estimated using the observations of actual mergers. Then, with the estimated merger policy function, the probabilities of potential mergers could be assigned to every states.

region-level HHI. The nationwide HHI in Japan's cement industry was already around 2,500, meaning that any merger between large firms would have been unlikely to be accepted by the Japan Fair Trade Commission (JFTC) if such a merger had been proposed.[67] Further, the HHI has been quite stable since the four mergers despite the sharp decline in cement demand (although the HHIs between 1998 and 2009 are not presented here). It therefore seems reasonable to assume that firms thought that any mergers between large firms were unlikely to take place in the (foreseeable) future. In addition, even a merger between a large and a small firm would have been unlikely. For instance, Taiheiyo's acquisition of Aso or Tokuyama or Ube-Mitsubishi's acquisition of Aso or Tokuyama would have been unlikely to be accepted, because the regions in the southern part of Japan, namely, the Kinki, Chugoku, Shikoku, and Kyushu regions, would have been significantly affected by such potential mergers.[68] On the other hand, mergers involving Sumitomo Osaka would have been more likely.

Therefore, if (further) mergers were expected to take place, they would have had to be one of the following five types of mergers. The first type is a merger between a large firm and a very small firm. The second type is a merger between a large firm and a small firm. The third type is a merger between small firms. The fourth is a merger between a small firm and a very small firm. And the fifth is a merger between very

[67] The JFTC employs the following HHI standard to desist from scrutinizing proposed mergers: (a) Mergers after which the market is moderately concentrated with an HHI of less than 1500. (b) Mergers after which the market is moderately concentrated with an HHI in the range of 1,500 to 2,500, but the increase in the HHI is less than 250. (c) Mergers after which the market is highly concentrated with an HHI of more than 2,500 but the increase in the HHI is less than 150. If a proposed merger satisfies one of these conditions, the proposed merger does not raise significant competitive concerns and is not scrutinized further by the JFTC.

[68] The JFTC scrutinized the Taiheiyo, Ube-Mitsubishi and Sumitomo Osaka mergers by taking into account not only the nationwide shares of the merged firms but also the shares in individual regions which were going to be affected by the mergers. Applying this standard for investigating the effect of mergers, the average increase in the HHI in the Kinki, Chugoku, Shikoku, and Kyushu regions as a result of the four potential mergers would be over 600, while the minimum increase in the regional HHI caused by the potential mergers would be 273. These increases in the HHI exceed the safe harbor standard for no scrutiny in the merger guidelines.

small firms.

The first type of merger would have posed few problems, since very small firms such as Hitachi and Ryukyu are very small and large firms, namely, Taiheiyo, Ube-Mitsubishi, and Sumitomo Osaka, would have become only marginally larger as a result of acquiring very small firms. For example, the size of merged firms would have increased by only one (or two) SS(s).[69]

The second type of merger would have been influential. Potential mergers of this type would have been mergers between Sumitomo Osaka and Tokuyama, Sumitomo Osaka and Aso, and Sumitomo Osaka and Nippon Steel. If firms expected these mergers to take place at sufficiently high probabilities, the model developed in this study, which does not consider the possibility of future mergers, might not be appropriate. However, small firms tended to operate only in a small number of regional markets, so that their overlap with the operations of Sumitomo Osaka was limited. For instance, even the most influential potential merger between Sumitomo Osaka and Tokuyama among possible mergers between a large firm and a small firm would not have affected all regions but only some regional markets, namely, the Kanto, Kinki, Chugoku, Shikoku, Kyushu regions.

As for mergers between small firms, these would also have been potentially problematic. For example, a potential merger between Aso and Tokuyama could have had a substantial impact on the Kinki, Chugoku, and Shikoku regions. However, small firms tended to operate only in a small number of regional markets, so that their overlap with the operations of other small firms was limited.

The last two types of mergers involving very small firms would have been less influential. Thus, these types do not cause any concerns in the analysis.

[69]These very small firms are not included in the current analysis in the paper because they are too small to be ranked among the five largest firms in any region.

In sum, there are two types of potential mergers that could have had influence on the industry, one involving Sumitomo Osaka and a small firm, and another between small firms. If firms actually expected (one of) them to take place, the model developed in this study will be inappropriate. As already mentioned, the effect of further mergers would have been limited to some regional markets, since the operations of firms that would have potentially been involved did not overlap completely. Nevertheless, it cannot be fully ruled out that the probability of potential mergers was non-negligible, so that there is a possibility that my estimation is subject to bias by not considering potential mergers. It is important to know how serious this potential bias is and what major biases are likely to arise.

To examine the effects of potential mergers on the current study, particularly on the estimation, an exercise where merger probabilities are added to the current model is conducted. The aim of this exercise is to discover whether and how the estimates obtained from the current specification without merger probabilities change when (exogenous) merger probabilities are introduced.

In this extended model, firms (in fact, managers in local headquarters) make divestment decisions, taking merger probabilities in the future as well as transition probabilities of state variables into account. However, it is the main offices that make merger decisions. In other words, while managers in local headquarters make divestment decisions (and decide supply) within the regions they are in charge of, they do not maker merger decision. Thus, for managers in local headquarters, mergers can be regarded as exogenous events in the sense that they do not decide on mergers and simply take the main office's decision as given. Such "exogenous mergers" may not be the best description of the reality, but it seems reasonable to assume that merger decisions are regarded not as region-specific decisions made by local managers but as inter-regional or nationwide decisions made by the main office.

By adding exogenous mergers to the model, the sequence of events in each period is modified a little. Local managers are assumed to know whether mergers take place at the very beginning of every period. Local managers then privately know the sell-off values and make divestment decisions as described in the paper. After all local managers have made their divestment decisions, competition in the product market takes place, given the current state variables. At the end of the period, each local headquarter earns the per-period profit from competing in the product market and receives the sell-off value of its SSs if it scrapped any. Firms' state variables then evolve following firms' divestments and the three exogenous state variables change. The sequence of events in each period unfolds as follows:

1. Firms (in fact, local managers) know whether mergers take place, and, if a merger takes place, firms involved in the merger are merged

2. Firms know the sell-off values of their SSs privately and observe the current demand and cost shifters.

3. Firms makes their divestment decisions simultaneously.

4. Given the current state variables, ς_t, firms compete with each other over quantity.

5. Firms obtain the per-period profits and receive the sell-off values if they sold off SSs.

6. The state variables evolve as the divestments are completed and new values of the exogenous variables are realized.

The only difference between the sequence described above and that in the paper is the presence of mergers at the beginning of the sequence of events.

Based on the above discussion on potential mergers, the following two hypothetical mergers are considered: a merger between Sumitomo Osaka and Tokuyama, and a merger between Aso and Tokuyama. The Sumitomo Osaka-Tokuyma merger is the largest plausible merger involving a large firm. The Aso-Tokuyama merger is a representative merger involving small firms that potentially influences the industry.

As in the setting outlined above, these two mergers are exogenous events in the future. Firms other than Aso, Sumitomo Osaka, and Tokuyama simply have expectations that there is a possibility that mergers involving Aso, Sumitomo Osaka, and Tokuyama will take place. On the other hand, Aso, Sumitomo Osaka, and Tokuyama expect themselves to be involved in a merger. After one of the mergers has taken place, Sumitomo Osaka and Tokuyama or Aso and Tokuyama become one firm and the two firms' SSs are simply the combined SSs of the two firms (and the more efficient firm's fixed effect is used for the post-merger firm). After one of the two mergers has taken place, the other does not take place. That is, once a merger takes place, the probability of the other goes to zero. It is thus assumed that only one merger takes place (although a positive probability is assigned to both mergers before the occurrence of a merger).

Because both mergers are hypothetical, probabilities for the mergers taking place are not estimated. It might be possible to infer merger probabilities by constructing a function of some observable variables and estimating it using mergers that actually took place in the past, as explained in footnote 66. However, instead of estimating the policy function for merger decisions, various probabilities to each merger are arbitrary assigned here.[70]

[70] The main goal in this exercise is not to estimate the model with (exogenous) mergers precisely, but to get a sense of whether the estimates obtained under the assumption that firms do not expect any further mergers and those obtained using the model with (exogenous) merger probabilities are reasonably similar to each other and, if they are different, how the difference affects the analysis of the paper.

The first is that the probability for each merger is 0.05 at every state. This means that within 10 years from the starting state, on average, one of the two mergers will take place. The second is that the probability for each merger is 0.1, meaning that within 5 years from the starting state, on average one of the mergers will take place. In addition to the probabilities of 0.05 and 0.1, I also use probabilities of 0.01 and 0.2 to examine more extreme cases.

The results are shown in Table 21.[71] The columns under (a) correspond to the estimates obtained under the specification without the two hypothetical mergers, which is the same specification as that used in the paper. The estimates of fixed costs obtained using the extended model with merger probabilities are relatively close to the estimates in the model without merger probabilities. On the other hand, the estimates of the sell-off value distribution are relatively different from those obtained in the paper. In particular, the estimates of the variance of the distribution vary, depending on the choice of merger probabilities. In addition, as to be expected, as merger probabilities get larger, the difference between the estimates obtained in the model without merger probabilities and those obtained here gets larger.

This simple exercise implies that it is possible that the estimation based on the model used in the paper is subject to non-negligible bias if firms expected that the potentially plausible mergers might take place. Specifically, any bias would be more severe for estimates of the variance of the sell-off value distribution. One of the reasons probably is that the divestment probabilities of the hypothetically merged firms - Sumitomo Osaka and Aso or Sumitomo Osaka and Tokuyama - would be higher than

[71]Standard errors for estimates of fixed costs and the sell-off value distribution are not calculated and reported. The merger probabilities should be estimated and the standard errors for the merger probabilities should be considered in the estimation of fixed costs and the sell-off value distribution. However, the merger probabilities are arbitrarily set in this exercise and, as a result, there are basically no significant difference from the standard errors reported in Table 12 in the paper.

those of the independent (not merged) firms, Sumitomo Osaka, Aso, and Tokuyama. Therefore, even with a low sell-off value, which would not lead independent firms to divest any SSs, the hypothetical merged firms might divest one or more SSs. Because of this increase in divestments with lower sell-off values, it is likely that estimates of the variance of the sell-off distribution get larger.

This exercise also implies that the welfare analysis in the paper is biased if firms indeed expected mergers to take place in the future. Generally speaking, because of the internalization of the business-stealing effect, the differentials in the value functions for merged firms are smaller than those for the original independent firms in the counterfactual. That is, the merged firms are more likely to divest SSs, given the realization of a particular sell-off value. Conversely, the original independent firms in the counterfactual need a higher sell-off value to divest their SSs. If the variance of the sell-off value distribution was larger, it is more likely that higher values are realized. Therefore, as the variance gets larger, original independent firms are more likely to receive sell-off values that are sufficiently high to induce them to divest SSs. In this case, the difference between the merged firms' and the independent firms' divestments likely gets smaller. This means that the fixed cost savings and the sell-off values received in both the actual and counterfactual environments get closer to each other. Therefore, the result from my counterfactual simulation would overstate the effect of the (realized) mergers on divestment.

However, even if the effect of the mergers on divestment and fixed cost saving was overstated, the result of the welfare analysis of the mergers would not change qualitatively. Remember that a merger has two effects on the marginal costs of the merged entity. The first is the synergy effect, which is the reduction in marginal costs achieved through the improvement in the firm fixed effect and combining two (or three) firms' SSs. The second effect is that a merger promotes divestments and, as a result, the marginal costs are negatively affected as time passes (because the coefficient on SSs in the marginal cost function is estimated to be negative).

However, the negative impact of a merger on marginal costs also becomes smaller as the variance gets larger. As explained above, in the case of the sell-off value distribution with a larger variance, it is more likely that the numbers of SSs divested in both the actual and counterfactual market structures get closer.

On the other hand, the synergy effect - the reduction in marginal costs achieved by combining two or three firms - is still present, since it simply arises from the merger itself and is not related to divestment (see the impact of the synergy effect at the time of the mergers on total welfare, which is presented in Table 15 in the paper). If the number of divestments becomes similar in both the actual and counterfactual environments, it is unlikely that total welfare, PS + CS, in both market structures gets closer as time passes. Instead, it is highly likely that, following the mergers, a situation similar to that at the time of the mergers will continue, since the number of divestments in both the actual and counterfactual environments tends to be similar. This means that the effect of the mergers on CS + PS is likely to be much larger than those presented in Table 14 in the paper. Therefore, even if firms actually expected further mergers to take place and the estimates of the sell-off value distribution were subject to bias, the result in the welfare analysis is (at least) qualitatively unaffected (given there are no significant differences in fixed cost savings and sell-off values).

Table 19: Nationwide Supply Shares and HHI

The Figures for Taiheiyo include those for its subsidiaries, DC, Mikawa-Onoda, Myojo, and Tsuruga. Similarly, those for Sumitomo-Osaka include Hachinohe and those for Aso include Kanda.

1998		2009	
Firm	Share	Firm	Share
Taiheiyo	38.2	Taiheiyo	35.7
Ube Mitsubishi	25.2	Ube Mitsubishi	27.8
Sumitomo Osaka	18.7	Sumitomo Osaka	16.8
Tokuyama	6.0	Tokuyama	6.8
Aso	3.0	Aso	3.9
Denka	2.6	Denka	2.7
Nippon Steel	2.1	Nippon Steel	2.7
Mitsui	1.7	Nittetsu	1.6
Nittetsu	1.4	Hitachi	1.1
Hitachi	1.1	Ryukyu	0.9
Ryukyu	0.8		
HHI	2506.8		2410.2

Table 20: Region-Level Supply Shares and HHI

THY stands for Taiheiyo, UM for Ube-Mitsubishi, SO for Sumitomo Osaka, TK for Tokuyama, AS for Aso, NS for Nippon Steel, DK for Denka, MT for Mitsui, HT for Hitachi, and NT for Nittetsu. Kanto includes both North and South Kanto regions and Okinawa is excluded from this table.

					1998						
	THY	UM	SO	TK	AS	NS	DK	MT	HT	NT	HHI
Hokkaido	49.20	16.86	3.91	0.00	0.00	0.00	3.94	0.00	0.00	26.08	3416.43
Tohoku	41.88	31.60	19.79	0.00	0.00	0.00	2.74	0.00	1.14	2.85	3160.74
Kanto	51.84	21.45	16.43	7.49	0.00	0.13	0.04	0.00	2.62	0.00	3480.75
Hokuriku	40.55	18.09	18.84	0.00	0.00	0.00	22.52	0.00	0.00	0.00	2833.80
Tokai	39.70	26.47	29.22	0.03	0.51	0.10	3.96	0.00	0.00	0.00	3146.89
Kinki	24.45	26.19	27.21	10.99	7.65	2.40	0.93	0.17	0.00	0.00	2210.62
Chugoku	33.46	30.42	10.67	14.97	5.77	3.54	0.00	1.18	0.00	0.00	2430.17
Shikoku	33.39	21.33	21.66	12.60	6.41	4.02	0.00	0.59	0.00	0.00	2255.29
Kyushu	30.78	28.35	8.28	9.84	12.44	7.61	0.00	2.70	0.00	0.00	2136.46
					2009						
	THY	UM	SO	TK	AS	NS	DK	MT	HT	NT	HHI
Hokkaido	45.86	14.00	8.87	0.00	0.00	0.00	4.37	0.00	0.00	26.91	3120.72
Tohoku	37.69	31.39	22.11	0.00	0.00	0.00	3.60	0.00	1.80	3.41	2922.38
Kanto	45.16	21.30	19.34	7.76	0.00	0.24	2.18	0.00	4.01	0.00	2948.66
Hokuriku	37.76	19.13	17.72	0.00	0.00	0.00	25.39	0.00	0.00	0.00	2750.47
Tokai	35.30	28.61	30.64	0.00	1.06	0.37	4.02	0.00	0.00	0.00	3020.79
Kinki	18.31	27.32	26.42	11.85	9.78	4.77	1.56	0.00	0.00	0.00	2040.66
Chugoku	32.24	26.98	9.95	20.37	5.24	5.21	0.00	0.00	0.00	0.00	2336.10
Shikoku	29.06	22.14	19.87	15.30	7.81	5.82	0.00	0.00	0.00	0.00	2058.61
Kyushu	18.84	43.18	7.15	10.41	12.29	8.13	0.00	0.00	0.00	0.00	2595.93

Table 21: Fixed Cost and Sell-off Value Distribution Estimates
"Merger Prob." indicates the (exogenous) merger probabilities of the hypothetical Sumitomo Osaka and Aso merger and the hypothetical Aso and Tokuyama merger. The row "Demand" shows the lower bound of the demand level used in the paper. The row "Policy Func." indicates the specification of the policy function used. (1) and (3) correspond to specifications (1) and (3) respectively in Table 9 in the paper.

	(a)	(b)	(c)	(d)	(e)
Merger Prob.	0.00	0.10	0.05	0.20	0.01
F_{ss}	80486.40	80251.89	79487.05	78049.20	80673.52
μ	28.70	24.83	26.13	23.80	27.69
κ	3.73	5.25	5.13	7.04	3.96
Demand			Optimistic		
Policy Func.			(1)		

	(a)	(b)	(c)	(d)	(e)
Merger Prob.	0.00	0.10	0.05	0.20	0.01
F_{ss}	69635.81	70122.16	68689.32	67884.94	70137.56
μ	32.02	27.92	29.18	27.10	30.91
κ	3.10	4.53	4.81	6.35	3.23
Demand			Intermediate		
Policy Func.			(1)		

	(a)	(b)	(c)	(d)	(e)
Merger Prob.	0.00	0.10	0.05	0.20	0.01
F_{ss}	61523.24	62597.11	62182.83	60386.91	62444.98
μ	33.85	29.76	30.77	29.05	32.69
κ	2.11	3.19	3.30	4.74	2.09
Demand			Pessimistic		
Policy Func.			(1)		

	(a)	(b)	(c)	(d)	(e)
Merger Prob.	0.00	0.10	0.05	0.20	0.01
F_{ss}	53724.17	63579.15	61334.31	63096.85	57326.79
μ	34.44	27.66	29.58	26.69	32.72
κ	2.34	5.04	4.18	6.69	2.46
Demand			Optimistic		
Policy Func.			(3)		

	(a)	(b)	(c)	(d)	(e)
Merger Prob.	0.00	0.10	0.05	0.20	0.01
F_{ss}	36774.28	49426.77	46080.91	50111.74	40872.73
μ	38.98	32.01	33.98	30.87	37.23
κ	1.71	3.88	3.04	5.37	1.58
Demand			Intermediate		
Policy Func.			(3)		

	(a)	(b)	(c)	(d)	(e)
Merger Prob.	0.00	0.10	0.05	0.20	0.01
F_{ss}	29546.40	40264.51	37190.13	40930.09	32706.25
μ	40.25	34.15	35.97	33.17	38.80
κ	1.53	3.48	2.64	4.86	1.38
Demand			Pessimistic		
Policy Func.			(3)		