Better Together? Performance Dynamics in Retail

Chain Expansion before and after Mergers*

Mitsukuni Nishida†
Johns Hopkins Carey Business School

Nathan Yang‡
Yale School of Management

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Abstract

This paper evaluates how mergers affect profitability of retail chains. Using manually collected panel data on convenience-store chains in Japan from 47 geographical markets, whereby an actual merger between two chains took place in 2001, we estimate a dynamic model of retail expansion. Given the presence of serially correlated unobservables that evolve endogenously and selection biases in sales, we combine recently developed particle-filtering methods for dynamic games with control functions in revenue regressions. We find that although the merged firm enhanced efficiency in sunk costs of expansion, underlying unobserved performance dynamics for the merged entity did not improve following the merger, and such changes in dynamics varied across markets. A counterfactual simulation reveals the slower growth of profitability is associated with the merged firm’s diminished ability to retain profitability from the previous period.

Keywords: Dynamic discrete choice; Entry; Industry dynamics; Learning-by-doing; Market concentration; Merger analysis; Particle filter; Revenue regression; Serial correlation; Retailing; Convenience store.

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†Email: nishida@jhu.edu.
‡Email: nathan.yang@yale.edu.
1 Introduction

Achieving synergy is easier said than done - it is not automatically realized once two companies merge. Sure, there ought to be economies of scale when two businesses are combined, but sometimes a merger does just the opposite. In many cases, one and one add up to less than two. Basics of Mergers and Acquisitions Investopedia (2010)

Ownership changes, such as mergers and acquisitions, affect the profitability of merging firms through various mechanisms. These mechanisms, as pointed out by Williamson (1968), may include enhanced cost efficiency and increased market power. A vast literature has acknowledged this efficiency component of profitability is not directly observable in data (e.g., Griliches, 1957) and likely evolves endogenously over time (e.g., Benkard, 2000, 2004). That said, how do mergers affect firms’ profitability dynamics?

Uncovering these performance dynamics is especially important for firms and policy makers in most industries in which mergers occur. For instance, a retail chain may be interested in understanding whether a merger boosts or disrupts these performance dynamics. Similarly, policy makers may be interested in evaluating how market structure and efficiencies evolve after the merger. Unfortunately, despite the importance of such potential effects of mergers, few empirical studies have examined how changes in ownership lead to changes in profitability over time. A prominent reason for this gap in the literature is the difficulty in observing the profitability of a firm. Because various tangible and intangible assets drive a firm’s profitability, observing and quantifying the profitability is difficult. Making such studies even more difficult, the profitability can evolve over time. Therefore, most of what we know about the impact of mergers on performance dynamics is limited to rare instances in which detailed information on performance is available.

This study analyzes firm-performance dynamics in retail growth, before and after a merger. Unlike previous studies that rely on detailed information on inputs and outputs (e.g., Braguinsky, Ohyama, Okazaki, and Syverson, 2014), this paper adopts a different approach. Namely, we use a

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1 For example, retail chains may wish to avoid a scenario like the Wendy’s and Arby’s merger in 2008. Within a few years of the merger, Wendy’s sold Arby’s to a private equity firm because of unexpectedly sluggish growth.

2 From a policy perspective, antitrust authorities may block a merger between multistore retailers when verifying the purported efficiencies from the merging firms is difficult. For instance, the U.S. Federal Trade Commission blocked a merger between Staples and Office Depot in 1997, two of the three largest nationwide office supply superstores. One of the major debates in the litigation concerned projected cost savings and the extent to which such efficiencies would be passed on to consumers (Baker, 1999).
dynamic oligopoly model to recover the profitability-dynamics process that justifies the observed data on store counts and sales by market, which are often publicly available through financial statements.

One of the interesting features of our setting is that we allow the equilibrium played to be different before and after year 2001, when sunkus and circle K are financially integrated into one entity. Namely, we estimate the model of dynamic expansion in our sample separately for pre- and post-merger time periods. This empirical strategy departs from existing studies, such as Benkard, Bodoh-Creed, and Lazarev (2010), who assume the equilibrium being played does not change after the merger. We are able to depart from this assumption, because the merger between sunkus and circle K is factual and not merely proposed.

Our model allows for the performance dynamics to operate flexibly through a serially correlated and unobserved profitability process. We estimate this model using an extensive and manually collected data set on all six major convenience-store chains in Japan, including 7-Eleven, in all 47 prefectures in Japan from 1982 to 2012. Note that our model captures both inter-firm (i.e., firm-specific model primitives)\(^3\) and intra-firm (i.e., market- and time-specific model primitives) heterogeneity in unobserved profitability dynamics. Given the presence of firm-specific and serially correlated unobservables, we make use of an approach akin to Blevins (2014) and Blevins, Khwaja, and Yang (2014) that combines particle-filtering methods with two-step estimation of dynamic-discrete choice games in a setting that has retail expansion and contraction. Because both revenue and store counts are observed in our data, the estimated model helps us determine the extent to which performance dynamics operate through demand (e.g., customer goodwill) or fixed costs (e.g., scale economies). A typical challenge of incorporating revenue into entry models is the inherent selection bias (i.e., we only observe non-zero revenues for markets in which the firms have at least one store). To address this challenge, we augment the particle-filtering method with the control function approach (e.g., Heckman, 1979) as proposed by Ellickson and Misra (2012) to correct for selection biases when we estimate revenue equations.

With the estimated structural model, we evaluate how the actual merger between circle K and sunkus in 2001 affected performance dynamics for two reasons. First, evaluating the dynamic

\(^3\)Inter-firm heterogeneity is largely motivated by the extensive literature that demonstrates inter-firm heterogeneity in performance. We refer the reader to Syverson (2011) for a summary of such work in the context of productivity.
aspect of performance for this merger is particularly relevant, because the publicized motive for this merger was to pursue “efficiencies of scale by integrating information systems and improving product margins through joint-purchasing negotiations,”\(^4\) while media observes that “many argue that it is [still] cost heavy,” even six years after the merger.\(^5\) Because of the prolonged merging process after the financial integration, the Japanese convenience-store expansion and revenue dynamics before and after the merger provide us an appropriate setting for evaluating performance improvements (or deterioration). Second, because this industry adopts uniform pricing, we are able to avoid the typical issue of confounding the effects of mergers on prices and on outlet expansion/contraction.

Our analysis yields three main findings. First, the estimates reveal that we do observe the merged entity enhanced efficiency in sunk costs of expansion. However, no noticeable improvements to the process behind performance dynamics following the merger existed. We associate the latter finding with the merged firm’s reduced ability to retain its unobserved profitability after merger. Namely, the posterior distribution of unobserved performance dynamics does not improve for the newly merged firm, because both the level and growth rate of the unobserved profitability actually decreases after the merger. Second, exploratory analysis of a hypothetical scenario in which the merged firm inherits the unobserved profitability process of circle K, the more dominant firm pre-merger (relative to sunkus), appears to better preserve the growth of unobserved profitability in the years following the merger. Finally, we find heterogeneity in the unobserved performance dynamics across various markets. In particular, we show that the drop in performance dynamics is most pronounced in markets with stagnated growth in the number of outlets, such as rural markets.

The rest of the paper is organized as follows. The remainder of Section 1 discusses the related literature. Section 2 provides details about the data and explains the institutional features of the industry and merger. Section 3 lays out the model we use for estimation and simulations. Section 4 goes over our estimation approach. Section 5 reports our parameter estimates and subsequent merger analysis. Section 6 concludes.


1.1 Related Literature

We contribute to the large literature on the relationship between ownership and firm performance. The existing studies offer mixed evidence. To support the notion of performance improving mergers, empirical work by Braguinsky, Ohyama, Okazaki, and Syverson (2014) and Maksimovic and Phillips (2001) suggest mergers may lead to increased profitability through more efficient use of capital. In fact, some governments are pursuing policies to consolidate state-owned businesses as a means to boost profitability.\textsuperscript{6} However, a merger need not necessarily lead to synergies and efficient reallocation of resources, because the newly combined firm will have the difficult task of integrating its corporate culture, logistics, marketing, and overall strategy (e.g., Larsson and Finkelstein, 1999; Weber and Camerer, 2003). For example, Schoar (2002) demonstrates that mergers lead to mixed results in performance, depending on whether the production plants within a conglomerate are incumbents or recently acquired, which ultimately leads to a net decrease in firm performance. In terms of incorporating mergers into dynamic oligopoly models, this paper is related to Benkard, Bodoh-Creed, and Lazarev (2010), Gayle and Le (2014), Hollenbeck (2013a), and Jeziorski (2014).\textsuperscript{7}

This paper contributes to the growing literature on mechanisms behind retail firms’ entry and expansion strategies. Retail chains may become increasingly profitable over time through performance dynamics such as improved customer goodwill (e.g., Basker, Klimek, and Van, 2012; Jovanovic and Rob, 1987; Pancras, Sriram, and Kumar, 2012; Shen and Xiao, 2014) or scale and network economies (e.g., Aguirregabiria and Ho, 2012; Ellickson, Houghton, and Timmins, 2013; Holmes, 2011; Jia, 2008; Nishida, 2015b). In data, such dynamics may materialize through persistence in market shares (e.g., Bronnenberg, Dhar, and Dubé, 2009). Furthermore, some of these performance advantages may persist over time via firm-specific abilities to retain efficient organizational-level processes (e.g., Darr, Argote, and Epple, 1995).\textsuperscript{8} However, a formidable challenge that empiricists face is that the underlying performance dynamics are inherently unobservable.

\textsuperscript{8}We refer the reader to Besanko, Doraszelski, Kryukov, and Satterthwaite (2010) for the theoretical framework behind learning-by-doing and organizational forgetting in industry dynamics.
with the unobserved nature of performance dynamics.

More broadly, this paper is related to the literature on retail chains’ expansion. Large retail chains, such as 7-Eleven, Wal-Mart, and McDonald’s, have expanded rapidly by entering multiple geographical markets and opening many outlets. Motivated by the growing dominance of chains in retail, the literature has received increasing interest from researchers (e.g., Beresteanu, Ellickson, and Misra, 2010; Blevins, Khwaja, and Yang, 2014; Hollenbeck, 2013b; Holmes, 2011; Igami and Yang, 2014; Nishida, 2015a; Orhun, 2013; Suzuki, 2013; Toivanen and Waterson, 2005, 2011; Varela, 2013; Vitorino, 2012; and Yang, 2012, 2013). In particular, an increasing number of empirical applications of industry dynamics now exploit information about revenues (Dunne et. al., 2013; Hollenbeck, 2013b; Suzuki, 2013).

Finally, this paper relates to the literature on applying particle-filtering methods to dynamic games. Blevins (2014) was the first to incorporate particle-filtering in the estimation of dynamic-discrete choice games of imperfect information, whereas Gallant, Hong, and Khwaja (2010) were the first to incorporate particle filtering in dynamic discrete-choice games of complete information. Recently, such methods have been also used in single-agent dynamic discrete-choice models such as Fang and Kung (2012).

2 Industry and Data

This section describes our data from the convenience-store chains in Japan (1982-2012). In our description of the industry, we also provide details about the merger between circle K and sunkus, which is one key industry feature that our data capture. Preliminary analysis suggests the presence of intertemporal performance dynamics that affect the firms’ future decisions, in that past size has a noticeable relationship with subsequent expansion efforts.

2.1 Market Definition, Data, and Merger Details

Japan has 47 prefectures, and each is a governmental body with a governor, and this paper treats these prefectures as 47 independent geographic markets. Given this definition of market, the

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9See Aguirregabiria and Suzuki (2015) for a recent survey of retail entry models.

10Marketing research has used linear and non-linear particle filtering methods in studying dynamic systems (e.g., Bass, Bruce, Majumdar, and Murthi, 2007; Bruce, 2008; Bruce, Foutz, and Kolsarici, 2012; Bruce, Peters, and Naik, 2012; Kolsarici and Vakratsas, 2010).
primary source of market-structure data is the annual financial statements from the six largest convenience-store chains (7-Eleven, LAWSON, Family Mart, circle K, sunkus, and ministop), which provide the prefecture-level annual sales and the number of stores for each chain. The coverage ranges from 1982 through 2012. The nominal sales across years are deflated by using the annual GDP deflator from the Cabinet Office.

The demographic variables come from multiple sources. Annual population data at the prefecture level come from the Census Bureau at the Ministry of Internal Affairs and Communications. Annual income data at the prefecture level come from the Cabinet Office. We compute the income per capita by markets by dividing the aggregate income at the prefecture level by the population of that prefecture. Hourly minimum wages at the prefecture level, published as the Annual Handbook of Minimum Wage Decisions, are collected by the Ministry of Health, Labour and Welfare. Annual land-price data for multiple points for each of the prefectures are published by the Ministry of Land, Infrastructure, Transport and Tourism, and we take the average across data points for each of the prefectures to construct the price index for that prefecture that year. Table 1 summarizes the variables we use in this paper. For each variable, we observe heterogeneity across chains, markets, and years.

We now describe a brief chronology of how sunkus and circle K, the fourth and fifth largest convenience-store chains in Japan, came to a financial integration in July 2001. Initially, they started their businesses separately. In 1980, Nagasakiya Co., Ltd, a large retailer in Japan focusing on clothes, established sunkus Co., Ltd. as a subsidiary company and opened its first outlet. Similarly, in the same year, UNY Co., Ltd, a licensee of circle K Stores, Inc. in the United States, established circle K Japan Co., Ltd. and opened its first outlet. Since then, circle K in Japan has been a subsidiary of UNY Co., Ltd. Meanwhile, sunkus experienced two ownership turnovers. In 1994, Nagasakiya Co., Ltd sold its shares of sunkus to Ono group. Four years later, UNY Co., Ltd. and circle K Japan Co., Ltd. started to form an alliance with sunkus by acquiring sunkus’ share. Afterwards, circle K and sunkus formed a holding company called C&S in 2001, under which both circle K and sunkus became subsidiaries. Although both sunkus and circle K are kept as separate chain brands, they increased the joint operations and management decisions under the holding company. The complete integration at the operation level took longer than the capital integration— in 2007 circle K and sunkus fully integrated their vendor and logistics networks.
Table 1: Summary Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min.</th>
<th>Max.</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Market Characteristics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Population</td>
<td>2666.614</td>
<td>2481.959</td>
<td>582</td>
<td>13230</td>
<td>10528</td>
</tr>
<tr>
<td>Income per capita</td>
<td>2590.847</td>
<td>538.132</td>
<td>1347.643</td>
<td>5232.25</td>
<td>9541</td>
</tr>
<tr>
<td>Minimum wage</td>
<td>572.532</td>
<td>99.094</td>
<td>400.709</td>
<td>910.064</td>
<td>10199</td>
</tr>
<tr>
<td>Land price</td>
<td>172256.776</td>
<td>211004.075</td>
<td>31860.813</td>
<td>2480561.209</td>
<td>9870</td>
</tr>
<tr>
<td><strong>Sales</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7-Eleven</td>
<td>56757.888</td>
<td>59292.341</td>
<td>31.045</td>
<td>364726.344</td>
<td>559</td>
</tr>
<tr>
<td>LAWSON</td>
<td>28733.695</td>
<td>32692.574</td>
<td>3346.591</td>
<td>261521.594</td>
<td>564</td>
</tr>
<tr>
<td>Family Mart</td>
<td>25832.317</td>
<td>35733.175</td>
<td>2.098</td>
<td>250225.5</td>
<td>668</td>
</tr>
<tr>
<td>sunkus</td>
<td>13943.18</td>
<td>15857.824</td>
<td>11.643</td>
<td>104912.438</td>
<td>327</td>
</tr>
<tr>
<td>circle K</td>
<td>18666.55</td>
<td>27488.137</td>
<td>119.161</td>
<td>174104.75</td>
<td>287</td>
</tr>
<tr>
<td>ministop</td>
<td>12246.53</td>
<td>12506.798</td>
<td>2.86</td>
<td>57916.926</td>
<td>329</td>
</tr>
<tr>
<td>CK+SKS</td>
<td>28680.531</td>
<td>38290.167</td>
<td>320.888</td>
<td>199770.516</td>
<td>259</td>
</tr>
<tr>
<td><strong>Number of outlets</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7-Eleven</td>
<td>277.139</td>
<td>274.59</td>
<td>1</td>
<td>1864</td>
<td>799</td>
</tr>
<tr>
<td>LAWSON</td>
<td>179.301</td>
<td>201.035</td>
<td>8</td>
<td>1549</td>
<td>795</td>
</tr>
<tr>
<td>Family Mart</td>
<td>144.308</td>
<td>189.698</td>
<td>1</td>
<td>1616</td>
<td>884</td>
</tr>
<tr>
<td>sunkus</td>
<td>76.605</td>
<td>77.528</td>
<td>1</td>
<td>506</td>
<td>509</td>
</tr>
<tr>
<td>circle K</td>
<td>116.309</td>
<td>163.987</td>
<td>1</td>
<td>902</td>
<td>417</td>
</tr>
<tr>
<td>ministop</td>
<td>77.382</td>
<td>73.744</td>
<td>1</td>
<td>308</td>
<td>380</td>
</tr>
<tr>
<td>CK+SKS</td>
<td>165.004</td>
<td>194.11</td>
<td>5</td>
<td>1007</td>
<td>259</td>
</tr>
</tbody>
</table>

2.2 Suggestive Evidence of Expansion

This subsection presents descriptive evidence on the expansion patterns of the convenience-store chains over years. Our interest here is to examine how a chain’s past size in a given market, measured by the total number of existing outlets, affects the subsequent year’s evolution of chains in the number of new outlets. Figure 1 plots the annual change in the number of outlets and the cumulative number of outlets for each chain. The horizontal and vertical axes are the cumulative number of outlets and the change in the number of outlets, respectively. These figures suggest this industry has faced competition in expanding a chain’s size in store counts in the data period.

To build on the findings from the diagram, we consider a simple linear regression specification that includes market fixed effects. Table 2 confirms that the lagged number of outlets positively affects the change in the number of outlets in the following year. Overall, these findings are suggestive of the presence of accumulated goodwill and/or scale economies in the industry. Furthermore, a comparison of our results across the chains demonstrates noticeable heterogeneity in these size effects.
Table 2: Effects of Lagged Number of Stores on Number of New Stores

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>-0.00366*</td>
<td>-0.00890***</td>
<td>-0.0151***</td>
<td>-0.00990***</td>
</tr>
<tr>
<td></td>
<td>(0.00152)</td>
<td>(0.00143)</td>
<td>(0.00148)</td>
<td>(0.00136)</td>
</tr>
<tr>
<td>Income per capita</td>
<td>0.00104</td>
<td>0.000625</td>
<td>-0.00220*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.000971)</td>
<td>(0.000983)</td>
<td>(0.001012)</td>
<td></td>
</tr>
<tr>
<td>Time trend</td>
<td>-0.398***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0420)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lagged # of stores</td>
<td>0.00357*</td>
<td>-0.00155</td>
<td>0.0117***</td>
<td>0.0205***</td>
</tr>
<tr>
<td></td>
<td>(0.00174)</td>
<td>(0.00167)</td>
<td>(0.00154)</td>
<td>(0.00150)</td>
</tr>
<tr>
<td>7-Eleven</td>
<td>9.619***</td>
<td>12.52***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.980)</td>
<td>(0.943)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LAWSON</td>
<td>1.909*</td>
<td>3.034***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.900)</td>
<td>(0.904)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Family Mart</td>
<td>3.156***</td>
<td>5.020***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.860)</td>
<td>(0.848)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>sunkus</td>
<td>-0.996</td>
<td>-0.569</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.914)</td>
<td>(0.925)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>circle K</td>
<td>-1.515</td>
<td>-0.666</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.969)</td>
<td>(0.978)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>circle K sunkus</td>
<td>-3.660**</td>
<td>-4.312***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1.188)</td>
<td>(1.202)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>25.84***</td>
<td>31.84***</td>
<td>62.60***</td>
<td>37.13***</td>
</tr>
<tr>
<td></td>
<td>(4.853)</td>
<td>(4.876)</td>
<td>(4.783)</td>
<td>(4.404)</td>
</tr>
<tr>
<td>Observations</td>
<td>3307</td>
<td>3307</td>
<td>3307</td>
<td>3387</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.32</td>
<td>0.30</td>
<td>0.21</td>
<td>0.21</td>
</tr>
</tbody>
</table>

Standard errors in parentheses

*p<0.05, **p<0.01, ***p<0.001
2.3 Expansion Dynamics for Merging Chains

We now direct our attention onto the expansion dynamics for circle K and sunkus, the two chains that financially integrated in 2001. A simple plot of the expansion patterns for the four largest chains with normalizing the number of outlets in 2001 as 100 (Figure 2) reveals an apparent decline for circle K’s and sunkus’s expansion trends after 2001; we see a similar slowdown for these two chains before and after the merger for aggregate sales (Figure 3).\(^{11}\) Prior to the merger, the total number and total sales of circle K and sunkus have been increasing the most rapidly among those four chains. After the merger, however, both the total sales and outlet counts for circle K and sunkus stagnated, unlike the other three chains, which continued to expand in size. To further investigate the possibility of a structural break in the expansion dynamics, we conduct a Chow test using the market-level sales and number of outlets and see whether the relationship between size and expansion (or change in sales) changes after the merger. Our test reveals that the null hypothesis of “no structural break” is rejected at 1% significance (Table 3).

Although such a test result suggests that mergers have an impact on performance dynamics, we are cautious about jumping to that conclusion based on this reduced-form evidence alone. To gain more robust insights about performance dynamics and the impact of mergers, we turn to

\(^{11}\) We interpret all years from 2002 onward as being post-merger years.
Table 3: Results from Chow Test for Structural Break in Relationship with Firm Size

<table>
<thead>
<tr>
<th></th>
<th>Expansion</th>
<th>Change in sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>F statistic</td>
<td>201.81***</td>
<td>104.76***</td>
</tr>
<tr>
<td>Controls</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Market fixed effects</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Time trend</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
our estimable model that allows for strategic and forward-looking expansion/contraction decisions, selection in revenue, and unobservable performance dynamics.

3 Model

We consider a model with $I$ forward-looking firms in a retail industry that make decisions about operating in market $m$ at time $t$. At the beginning of time period $t$ and for each given market $m$, each firm decides how many new stores to add or subtract, denoted as $n_{imt}$ \(\in N_i = \{-K_i, ..., -1, 0, 1, ..., K_i\}\). Based on this decision, the total number of stores that a firm has in market $m$ and time $t$ evolves according to

\[ N_{imt} = N_{imt-1} + n_{imt}. \]

A current period’s market structure can then be summarized as $N_{mt} = \{N_{imt}\}_i$.

Firms are forward-looking and seek to maximize the discounted profit stream $\sum_s \rho^s \Pi_{imt+s}$, where $\Pi_{imt}$ is the one-shot payoff as defined by

\[ \Pi_{imt}(n_{imt}, N_{mt-1}, X_{mt}, Z_{imt}, \zeta_{imt}, \xi_{imt}; \theta) = R_i(n_{imt}, N_{mt-1}, X_{mt}, Z_{imt}, \zeta_{imt}^R, \xi_{imt}^R; \theta^R) - C_i(n_{imt}, N_{mt-1}, X_{mt}, Z_{imt}, \zeta_{imt}^C, \xi_{imt}^C; \theta^C), \]

where $\theta$ denotes a set of parameters. The one-shot payoff consists of two main components: the revenue and the cost. Here, revenue is denoted by $R_i(\cdot)$. Revenue is a function of the number of active outlets the chain has in the market ($N_{imt}$), market characteristics ($X_{mt}$), and the competitive landscape ($N_{-imt}$). The market characteristics may be categorized as being specific to revenue ($X_{mt}^R$) or cost ($X_{mt}^C$). We assume here that firms play a game of incomplete information, as in Seim (2006), so $\zeta_{imt} = (\zeta_{imt}^R, \zeta_{imt}^C)$ can be interpreted as private information that is i.i.d. (across markets and time) with Type I Extreme Value distribution. Similar to Ellickson and Misra (2012), we also include optimization error, $\xi_{imt} = (\xi_{imt}^R, \xi_{imt}^C)$. Unlike $\zeta_{imt}$, the optimization error will not have an impact on firm behavior, such that they are ignored when we construct best-response functions. For example, we can think of such optimization errors as idiosyncratic miscalculations in forecasted revenue or costs during pro forma real estate analysis prior to expansion. Similar
to Blevins, Khwaja, and Yang (2014), we allow for a firm-specific profitability that varies across markets and time and is unobserved by the econometrician, as denoted by $Z_{imt}$:

$$R_i(n_{imt}, N_{mt-1}, X_{mt}, Z_{imt}, \zeta^R_{imt}, \xi^R_{imt}, \theta^R) = N_{imt}(\theta^R_1 + \theta^R_2 X_{mt} + \theta^R_3 N_{imt} + \theta^R_4 N_{-imt}) + \gamma^R Z_{imt} + \zeta^R_{imt} + \xi^R_{imt}.$$ 

Cost is denoted by $C_i(\cdot)$:

$$C_i(n_{imt}, N_{mt-1}, X_{mt}, Z_{imt}, \zeta^C_{imt}, \xi^C_{imt}, \theta^C) = \theta^C_1 X_{mt} + \theta^C_2 \cdot 1\{N_{imt-1} = 0, n_{imt} > 0\} + \theta^C_3 \cdot 1\{n_{imt} > 0\} \cdot n_{imt} + \theta^C_4 \cdot 1\{n_{imt} < 0\} \cdot n_{imt} - \gamma^C Z_{imt} + \zeta^C_{imt} + \xi^C_{imt},$$

where $\theta^C_1, \theta^C_2, \theta^C_3$, and $\theta^C_4$ are parameters for market characteristics, entry costs, expansion costs, and contraction costs, respectively. Similar to revenue specification, we allow for a private-information shock and optimization error. Furthermore, unobserved profitability may affect the fixed-cost component of profits. Because the unobserved profitability enter into both revenue and cost, comparisons between $\gamma^R$ and $\gamma^C$ would be helpful in determining the extent to which unobserved profitability matters for revenue and cost, respectively.$^{12}$

A key difference between our model and typical dynamic oligopoly models of entry is the inclusion of a serially correlated and unobserved profitability term. We assume this unobserved profitability follows a simple autoregressive process, which the following transition equation captures:

$$Z_{imt} = \mu_i + \delta_i Z_{imt-1} + \beta_i N_{imt-1} + \eta_m + \epsilon_{imt},$$

where $\epsilon_{imt} \sim N(0, \psi^2)$ are i.i.d. This unobserved profitability measure has two main components. The first component, $\delta_i$, is the persistence of profitability (i.e., retention). The second component,
$\beta_i$, is related to movements along the learning curve as the chain’s size in a given market that changes over time (i.e., size spillover)\textsuperscript{13}. Finally, $\epsilon_{imt}$ are normally distributed i.i.d. innovations to unobserved profitability with standard deviation $\psi_e$. Different parameters across firms capture heterogeneity across firms. Ultimately, this specification allows for firm-market-specific unobserved heterogeneity that is potentially serially correlated. We make the assumption that $Z_{imt}$ is observed by all firms, but unobserved to the econometrician. However, the model allows for some elements of a firm’s profitability to be private information incorporated in $\zeta_{imt}$.

We represent the model’s structural parameters as $\alpha = \{\alpha_i\}_{i=1}^f$, where

$$\alpha_i = (\theta_{i1}^R, \theta_{i2}^R, \theta_{i3}^C, \theta_{i4}^C, \theta_{i5}^R, \theta_{i6}^C, \gamma_i^R, \gamma_i^C, \mu_i, \delta_i, \beta_i, \eta_m, \psi_e).$$

Given the current pay-off-relevant state $s_{imt} = (N_{mt-1}, X_{mt}, Z_{imt}) \in S$, which is known to all players, the firm’s expected total discounted profit at time $t$ prior to the private shock $\zeta_{imt}$ being realized is given by,

$$\mathbb{E}\left[\sum_{\tau=t}^{\infty} \rho^{\tau-t} \{\Pi_{imt}(s_{im\tau}, \zeta_{im\tau}; \alpha_i)\} \right],$$

where $\rho$ is the discount factor, $\rho \in (0, 1)$. The firm’s objective is to maximize the present discounted value of its profit at each time period $t$, taking as given the equilibrium action profiles of other firms. The expectations are over the rivals’ actions in the current period, the future evolution of the state variables, and the private information shock to the firm in the current period.

We follow Bajari, Benkard, and Levin (2007) and analyze the dynamic game of incomplete information using the solution concept of pure strategy Markov perfect equilibria (MPE).\textsuperscript{14} We use the following notation to set up the MPE. A Markov strategy for a firm is a map from its payoff-relevant state variables and private information to its set of actions, that is, $\sigma_{imt} : S \times \mathbb{R} \rightarrow N_i$. Furthermore, a profile of Markov strategies is the vector $\sigma_{imt} = (\sigma_{1mt}, \ldots, \sigma_{fimt})$, where $\sigma : S \times \mathbb{R}^f \rightarrow N$. A MPE is defined as a Markov strategy profile $\sigma_{imt}$, such that no firm has an incentive to deviate from its strategy. Thus, there is no firm $i$, with an alternative Markov strategy $\sigma'_{imt}$, that it prefers to the strategy $\sigma_{imt}$ with its rivals using the strategy profile $\sigma_{-i,mt}$. More formally, $\sigma_{imt}$ is defined to be an MPE if for all firms $i$, in all stages $s_{imt}$, and for all alternative Markov strategies $\sigma'_{imt}$, the

\textsuperscript{13}Refer to Benkard (2000, 2004) for a similar econometric specification for learning-by-doing in production. Alternatively, one may interpret this specification as capturing network effects or scale economies.

\textsuperscript{14}Refer to Ericson and Pakes (1995) for the general MPE framework.
following condition holds:

\[ V_i(s_{imt}, \zeta_{imt}|\sigma_{imt}, \sigma_{-i,imt}) \geq V_i(s_{imt}, \zeta_{imt}|\sigma'_{imt}, \sigma_{-i,imt}) \quad \forall \ i, m, t. \]

Given a Markov strategy profile \( \sigma_{imt} \), the ex-ante value function and the associated Bellman equation for the present discounted value of the stream of profits for firm \( i \) can be written as,

\[ V_i(s_{imt}, \zeta_{imt}|\sigma_{mt}) = \mathbb{E}_{\zeta_{-i,imt}}[\Pi_{imt}(\sigma_{mt}(s_{mt}, \zeta_{mt}), s_{imt}, \zeta_{imt}) + \rho \mathbb{E}_{t+1}[V_i(s_{im,t+1}, \zeta_{im,t+1}|\sigma_{mt})]], \]

where \( s_{mt} = (s_{1mt}, \ldots, s_{Imt}) \) and \( \zeta_{mt} = (\zeta_{1mt}, \ldots, \zeta_{Imt}) \). The expectations \( \mathbb{E}_{\zeta_{-i,imt}} \) are with respect to current values of the private shocks and hence current actions of rivals, and the expectations \( \mathbb{E}_{t+1} \) are with respect to future values of all state variables, future values of private shocks for the firm and its rivals, and future actions of rivals.

4 Estimation

To estimate the model of retail dynamics, we combine recently developed particle-filtering methods for dynamic games and control-function methods in revenue regressions, which will address the following two key issues. First, we follow Blevins, Khwaja, and Yang (2014) to pair flexible particle-filtering techniques with the Bajari, Benkard, and Levin’s (2007) two-step method. This approach allows for serially correlated and firm-specific unobservables in a dynamic model of retail expansion.\(^{15}\) Second, because our analysis makes use of revenue data, controlling for potential selection biases in revenues is important. To address this issue, we follow Ellickson and Misra (2012) to employ propensity-score-based methods.

Our estimation approach proceeds in the following three steps. First, we estimate each firm’s beliefs via pre-merger and post-merger policy-function approximation, while employing particle filtering to obtain the posterior distribution of the serially correlated unobservable. Second, we use the approximated policies to estimate selectivity-corrected revenue equations via regression; note that because we are using pre-merger and post-merger policy functions, we run the revenue regres-

\(^{15}\)Similar to Blevins (2014), we use a bootstrap particle filter (Gordon, Salmond, and Smith, 1993).
sions separately before and after the merger. Finally, using the calibrated revenue equations, we construct trajectories of profits using forward simulations, and estimate remaining cost parameters via Bajari, Benkard, and Levin (2007). We obtain standard errors using block bootstrapping.

4.1 Policy-Function Approximation and Particle Filtering

The objective of our first-stage estimation is to estimate jointly the posterior distributions for the serially correlated unobservables $Z_{imt}$, as well as the reduced-form policy functions for each of the retail chains. These reduced-form policy functions are meant to approximate each chain’s decision regarding its expansion or contraction decision, $n_{imt}$.

As before, we denote $X_{mt}$ to be the vector of exogenous state variables, such as population, income, whereas $Z_{mt} = \{Z_{imt}\}_i$ are vectors for the serially correlated unobservable state variables. For brevity, let us collect all reduced-form parameters pertaining to the first stage into $\phi$, which include the coefficients for the reduced-form policy, market fixed effects, and the parameters in the transition of $X_{mt}$ and $Z_{mt}$. Given the data $\{n_{mt}, X_{mt}\}$, we maximize the following likelihood function:

$$L(\phi) = \prod_m \prod_t \int l_m(n_{mt}|X_{mt}, Z_{mt}, N_{mt-1}, \phi)p(X_{mt}|X_{mt-1}, \phi)p(Z_{mt}|N_{mt-1}, X_{mt-1}, \phi)dZ_{mt}.$$ 

The likelihood consists of three main components. First, we estimate the firm-specific choice probabilities $l_m$ via an ordered probit (see Appendix B for details). The order probit uses sieve maximum likelihood that includes all exogenous variables and relevant interactions. Second, we have the transition probabilities for the exogenous characteristics, $p(X_{mt}|X_{mt-1}, \phi)$; we estimate these transition probabilities using a seemingly unrelated regression (SUR), because the evolution of these characteristics may be correlated across markets. The final component is $p(Z_{mt}|N_{mt-1}, X_{mt-1}, \phi)$, which are the posterior distributions for the serially correlated unobservables. Given an initial distribution for the unobserved state and the recursive relation, we can simulate entire sequences for these posterior distributions.

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16 Appendix D discusses the details regarding how we incorporate the merger event.
17 In this likelihood, we are also taking a product across all firms $i$. To maintain consistency in our notation regarding the actions and pay-off relevant states, we omit $\prod_i$ and chain subscript $i$ in the paper’s exposition.
18 See Appendix A for more details.
We can then perform the filtering step using the following:

\[
p(Z_{mt}|N_{mt-1}, X_{mt-1}, \phi) = \frac{l_m(n_{mt-1}, X_{mt-1}|X_{mt-2}, N_{mt-2}, Z_{mt-1}, \phi)p(Z_{mt-1}|N_{mt-2}, X_{mt-2}, \phi)}{\int l_m(n_{mt-1}, X_{mt-1}|X_{mt-2}, N_{mt-2}, Z_{mt-1}, \phi)p(Z_{mt-1}|N_{mt-2}, X_{mt-2}, \phi)dZ_{mt-1}}.
\]

Here, we update the posterior distribution for \(Z_{mt}\) using the joint probability distribution for \((n_{mt-1}, X_{mt-1})\). More specifically, our first-stage policy estimation implements the particle filtering (i.e., sequential Monte Carlo) using the following steps:

1. **Initialization:** Draw \(Z^r_{mt}\) from some distribution for each simulation draw \(r = 1, \ldots, R\).

2. **Recursion:** Repeat the following steps for each \(t = 1, \ldots, T\).
   - **Importance sampling:** Draw \(Z^r_{mt}\) based on the transition equation for the \(Z\) process, and set weights according to \(w^r_t = l_m(n_{mt-1}, X_{mt-1}|X_{mt-2}, N_{mt-2}, Z^r_{mt-1}, \phi)\) for each simulation draw \(r = 1, \ldots, R\). Note that \(l_m(n_{mt}|X_{mt-1}, N_{mt-2}, Z_{mt}, \phi)\) is the probability of observing \(n_{mt}\) given the state \(X_{mt-1}\), and drawn values of \(Z^r_{mt}\).
   - **Re-sampling:** For each simulation draw \(r = 1, \ldots, R\), draw posterior values \(\tilde{Z}^r_{mt}\) from collection of \(Z^r_{mt}\), in proportion to the weights, \(w^r_t\), computed in the previous step.

The incorporation of particle filtering helps integrate out the serially correlated unobservables via sequential Monte Carlo re-sampling procedures, whereby the posterior distribution for the sequence of serially correlated unobservables is successively updated with each simulation draw.\(^{19}\)

We use \(R = 1,000\) simulation draws (i.e., particle “swarms”).

### 4.2 Estimating the Revenue Function

Our analysis makes use of the fact that we observe firm-specific revenues. In general, the realized revenues may suffer from selection bias that is induced by the underlying dynamic game of

---

\(^{19}\) An alternative way to integrate out the unobserved states is the expectation-maximization method by Arcidiacono and Miller (2011). We choose to deviate from popular convention for the following reasons. First, incorporating continuous unobserved states using particle filtering, as opposed to Arcidiacono and Miller’s (2011) method that works particularly well for discrete persistent or time-varying unobserved Markovian states, is practically easier. However, the incorporation of discrete unobserved states will require an \textit{a priori} assumption about the number of unobserved types. Second, and most importantly, we are interested in an unobserved state that evolves both endogenously (through past size \(N_{mt-1}\)), and stochastically (through draws of \(\epsilon_{imt}\)).
expansion, because revenues are only observed for the strategies that are played in equilibrium. Strategies are chosen that maximize discounted profits, and are a function of the same unobserved private shocks that affect revenues, $\zeta_{imt}^R$. Denoting the composite shock as $\omega_{imt}^R = \zeta_{imt}^R + \xi_{imt}^R$, it becomes clear that given this selection bias, $E(\omega_{imt}^R|n_{imt} = k) \neq 0$.

To address the selection bias described above, we follow Ellickson and Misra (2012) and adopt a propensity-based method. This procedure amounts to running revenue regressions, with the inclusion of a control function $\Lambda(\hat{n}_{imt})$. The argument for how a control function addresses the selection bias is laid out in the Appendix of Ellickson and Misra (2012); in their discussion, they demonstrate equivalence between the control function, and the expectation of $\omega_{imt}^R$ conditional on being active. Here, the control function depends on $\hat{n}_{imt}$, which is the predicted number of opened/closed outlets as determined using the first-stage policy approximation. The main revenue regression is therefore defined as

$$R_{imt} = N_{imt}(\theta_1^R + \theta_2^R X_{imt} + \theta_3^R N_{imt} + \theta_4^R N_{imt}^2) + \Lambda(\hat{n}_{imt}) + \gamma^R \tilde{Z}_{imt} + \tilde{\omega}_{imt},$$

where we choose a simple third-order polynomial for $\Lambda(\hat{n}_{imt})$.\(^{20}\)

### 4.3 Estimating the Cost Function

The final stage of our estimation proceeds using Bajari, Benkard, and Levin’s (2007) forward simulation approach, which allows us to recover the cost parameters given the estimated first-stage parameters $\phi$ and the revenue parameters. The estimated first-stage parameters allow us to forward simulate the policies, exogenous state variables, and serially correlated unobserved states. To proceed with the inference, we assume the data are generated by a single MPE strategy, which is a typical assumption when using two-step estimation methods. Unlike nested fixed-point estimation methods, this assumption does not require us to state anything about the particular equilibrium selection; we are assuming the equilibrium selection is the same across markets.

\(^{20}\)See Appendix C for more details on the implementation.
For any given initial state $S_1 = (N_0, X_1, Z_1)$, we can then forward simulate the following:

$$
\bar{V}_i(S_1; \sigma, \alpha) = \mathbb{E} \left[ \sum_{\tau=1}^{\infty} \rho^{\tau-1} \Pi_i(\sigma(S_\tau, \nu_\tau), S_\tau, \nu_{i\tau}; \alpha) \mid S_1, \sigma \right]
$$

$$
\simeq \frac{1}{S} \sum_{s=1}^{S} \sum_{\tau=1}^{T} \rho^{\tau-1} \Pi_i(\sigma(S_{s\tau}^s, \nu_{s\tau}^s), S_{s\tau}^s, \nu_{s\tau}^s; \alpha).
$$

Subscript $s$ represents each simulation, where $\bar{S}$ paths of length $T$ are simulated in the second stage. The term $\sigma(S_{r\tau}^s, \nu_{r\tau}^s)$ denotes a vector of simulated actions based on the policy profile $\sigma$. With this construction of forward-simulated actions and payoffs, we can then consider perturbations of the policy function to generate $B$ alternative policies. With each alternative policy, we can obtain the forward-simulated profit stream using the previous two steps. We let $b$ index the individual inequalities, with each inequality consisting of an initial market structure and state $S_1^b = (N_0^b, X_1^b, Z_1^b)$, an index for the deviating firm $i$, and an alternative policy $\tilde{\sigma}_i$ for firm $i$. The difference in valuations for firm $i$ using inequality $b$ is denoted by

$$
g_b(\tilde{\sigma}, \alpha) = \bar{V}_i(S_1^b; \tilde{\sigma}, \alpha) - \bar{V}_i(S_1^b; \tilde{\sigma}_i, \tilde{\sigma}_{-i}, \alpha).
$$

This difference should be positive in equilibrium. Therefore, this criterion listed below identifies a $\tilde{\alpha}$ to minimize the violations of the equilibrium requirement:

$$
Q(\alpha) = \frac{1}{B} \sum_{b=1}^{B} (\min\{g_b(\tilde{\sigma}, \alpha), 0\})^2.
$$

We use $B = 1,000$ simulated inequalities.

4.4 Identification

We now discuss the identification of strategic effects, revenue regression parameters, and the unobserved profitability process.

Identification conditions for models with strategic interactions (i.e., $\theta^R_4$) are well known. A common strategy is to make use of exclusion restrictions, which affect one firm’s payoffs directly, but not the payoffs of other firms. For our analysis, we make use of the lagged size of the firm, because it affects the firm directly through the unobserved profitability process and sunk costs,
while having no direct effect on its rivals’ payoffs. It will, however, have an indirect impact on rivals through their beliefs about the firm’s expansion or contraction strategies.

To identify the underlying parameters in revenue, we make use of another exclusion restriction. More specifically, we have variables (e.g., wages, property value) that should have an impact on cost \( (X^C_{mt} \neq X^R_{mt}) \), but not revenue. These cost-side variables have an impact on the strategies, but can be excluded from the regression specification. As Ellickson and Misra (2012) suggested, property value is likely the better candidate as an exclusion restriction, because we can better interpret it as a market characteristic that affects sunk costs.

The unobserved profitability process \( (\mu_i, \delta_i, \beta_i, \eta_m) \) is identified by the exclusion restriction involving the states that enter revenue and cost directly, but not unobserved profitability. For example, beliefs about a rival’s current size is relevant for revenue but does not have an impact on the unobserved profitability process. Furthermore, revenue and cost shifters, such as population, income, minimum wage, and property value, enter the payoffs, but not the unobserved profitability. Finally, intertemporal volatility of these exogenous states also ensure they do not mirror the market fixed effect found in the evolution of unobserved profits. With these exclusion restrictions, the posterior distribution for the unobserved profitability can be identified, which can then be used to obtain the underlying parameters in unobserved profitability. In the absence of such exclusion restrictions, the identification strategy presented by Hu, Shum, and Tan (2010) suggests that a necessary (but not sufficient) requirement for identification of dynamic games with serial correlation includes a long panel, and rich transitions in the observed states, both of which our data easily satisfy.

Note that one added layer of richness in our specification is that the unobserved profitability is weighted differently in revenue \( (\gamma^R) \) than in cost \( (\gamma^C) \). Consequently, our estimation method aims to identify these weights. To identify the role of unobserved profitability in revenue, we make use of the fact that the posterior distribution of unobserved profitability is identified via our earlier arguments. Knowing the posterior distribution, we can then project them onto revenue and obtain \( \gamma^R \) via our revenue regressions. With the revenue portion of profit identified, we can identify the role of unobserved profitability on cost via similar identification arguments used to identify the various sunk costs (i.e., revealed preferences in the sequence of actions). In particular, \( \gamma^C \) is identified separately from the other parameters in sunk cost given its autoregressive structure that
Table 4: Estimates for the Unobserved Profitability Process before Merger

<table>
<thead>
<tr>
<th>7-Eleven</th>
<th>LAWSON</th>
<th>Family Mart</th>
<th>sunkus</th>
<th>circle K</th>
<th>ministop</th>
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</thead>
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<tr>
<td>Firm FE ($\mu$)</td>
<td>0.0120</td>
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<td>0.1630</td>
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<td>0.1508</td>
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Standard errors in parentheses

Table 5: Estimates for the Unobserved Profitability Process after Merger

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<th>Family Mart</th>
<th>ministop</th>
<th>cK+sunkus</th>
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<td>Retention ($\delta$)</td>
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<td>Size spillover ($\beta$)</td>
<td>0.8940</td>
<td>0.0289</td>
<td>0.4950</td>
<td>0.7202</td>
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</table>

Standard errors in parentheses

incorporates information about firm size well before the previous year.

Finally, there is the issue of initial conditions for the unobserved profitability process ($Z_{im0}$). For this reason, we need to make use of a parametric estimation method; consequently, we estimate the distribution of the unobserved profitability process, not the actual values. Furthermore, the fact that our data encompass the entire evolution of the convenience-store industry, we do observe the initial period of data in each market. Lastly, the importance-sampling aspect of particle filtering exponentially reduces the impact of our parametric initial distribution assumption with each updating and re-sampling iteration (Whiteley, 2012).

5 Empirical Results

5.1 Parameter Estimates

We begin by reporting the estimates from the first stage pertaining to the unobserved profitability process (Tables 4 and 5).\textsuperscript{22}

\textsuperscript{21}Blevins (2014) demonstrates such features of particle filtering in his Monte Carlo experiments.

\textsuperscript{22}The full set of estimates for the parametrized first stage are available upon request.
Table 6: Estimates from the Revenue Regressions before Merger

<table>
<thead>
<tr>
<th></th>
<th>7-Eleven</th>
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<th>Family Mart</th>
<th>sunkus</th>
<th>circle K</th>
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<td></td>
<td>(0.0001)</td>
<td>(0.0014)</td>
<td>(0.0013)</td>
<td>(0.0046)</td>
<td>(0.0059)</td>
<td>(0.0013)</td>
</tr>
<tr>
<td>Unobserved profitability ($\gamma^{(R)}$)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.9781</td>
<td>1.1883</td>
<td>7.832e-07</td>
<td>0.4181</td>
<td>1.214e-08</td>
<td>0.2247</td>
</tr>
<tr>
<td></td>
<td>(0.0702)</td>
<td>(0.0698)</td>
<td>(0.0000)</td>
<td>(0.0075)</td>
<td>(0.0000)</td>
<td>(0.0092)</td>
</tr>
</tbody>
</table>

Standard errors in parentheses

As for the merged firms, sunkus and circle K, the merger appears to have led to lower retention and size-spillover effects for the merged firm, while raising the firm fixed effect. Therefore, the estimates from the Z process provide no evidence that the merger improved the underlying performance dynamics for sunkus and circle K. For instance, the merged firms’ increased size may not fully exploit cost efficiencies from size in the number of outlets, such as reducing transportation costs through a denser distribution network. We come back to this issue in the next subsection when we quantify how these changes in the magnitude will drive the trajectory of the Z process in monetary units.

We observe two patterns for all the chains. First, noticeable inter-firm heterogeneity exists in these estimates across chains. For instance, before the merger, the retention effect ($\delta$) is largest for circle K, whereas the size-spillover ($\beta$) is largest for ministop. After the merger, Family Mart and 7-Eleven have the largest retention and size spillover estimates, respectively. Second, we observe noticeably different unobserved profitability processes before and after the merger for all chains.

We turn to the main results from our revenue regressions before and after the merger in Tables 6 and 7, respectively.

First note that unobserved profitability has a noticeable effect through revenue for all chains except circle K and Family Mart prior to the merger, but only LAWSON after the merger. This finding suggests a diminishing role that the unobserved profitability process plays through rev-

---

23 These estimates are comparable across chains because the process is initialized using the same initial standard normal distribution.
Table 7: Estimates from the Revenue Regressions after Merger

<table>
<thead>
<tr>
<th></th>
<th>7-Eleven</th>
<th>LAWSON</th>
<th>Family Mart</th>
<th>ministop</th>
<th>cK+sunkus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant ($\theta_1^R$)</td>
<td>4.8152</td>
<td>57.2905</td>
<td>60.1369</td>
<td>106.5308</td>
<td>148.7529</td>
</tr>
<tr>
<td>Population ($\theta_2^{R,\text{population}}$)</td>
<td>(1.4622)</td>
<td>(1.5969)</td>
<td>(1.1258)</td>
<td>(0.8825)</td>
<td>(0.7558)</td>
</tr>
<tr>
<td>Income ($\theta_2^{R,\text{income}}$)</td>
<td>0.0207</td>
<td>-0.0101</td>
<td>-0.0019</td>
<td>-0.0074</td>
<td>0.0032</td>
</tr>
<tr>
<td></td>
<td>(0.0006)</td>
<td>(0.0001)</td>
<td>(0.0001)</td>
<td>(0.0003)</td>
<td>(0.0002)</td>
</tr>
<tr>
<td>$N_i$ ($\theta_3^R$)</td>
<td>0.0220</td>
<td>0.0489</td>
<td>0.0414</td>
<td>0.0272</td>
<td>0.0015</td>
</tr>
<tr>
<td></td>
<td>(0.0002)</td>
<td>(0.0002)</td>
<td>(0.0001)</td>
<td>(0.0004)</td>
<td>(0.0000)</td>
</tr>
<tr>
<td>$N_{-i}$ ($\theta_4^R$)</td>
<td>-0.0923</td>
<td>0.0507</td>
<td>-0.0157</td>
<td>-0.1920</td>
<td>0.0274</td>
</tr>
<tr>
<td></td>
<td>(0.0066)</td>
<td>(0.0006)</td>
<td>(0.0018)</td>
<td>(0.0092)</td>
<td>(0.0057)</td>
</tr>
<tr>
<td>Unobserved profitability ($\gamma^R$)</td>
<td>4.195e-12</td>
<td>5.2619</td>
<td>3.857e-11</td>
<td>3.734e-11</td>
<td>7.309e-06</td>
</tr>
<tr>
<td></td>
<td>(0.0000)</td>
<td>(0.2126)</td>
<td>(0.0000)</td>
<td>(0.0000)</td>
<td>(0.0000)</td>
</tr>
</tbody>
</table>

Standard errors in parentheses

As for the merged firms, three noticeable changes emerge. First, the lack of contribution from the demand side may be related to the fact that both chain brands are kept separate after the merger, such that they might have been unable to fully exploit the merger event to increase sales. Second, we see that the own-brand cannibalization effects that sunkus experiences prior to the merger dampens after the merger, as the number of outlets on revenue for the merged firm becomes positive. This finding suggests that the merged chains may expand and locate in such a way that they minimize cannibalization of the two brands. Finally, the competition effect $\theta_4^R$ becomes negative after the merger, such that rival firms exert business stealing effects. As the merger appears to spur the unobserved profitability processes for rival chains, competition may be somewhat intensified after the merger.

Revenues are a positive function of the income for some chains such as 7-Eleven, Family Mart, and circle K. After the merger, income has a positive effect on all of the chains. Competition appears to have a dampening effect on the own size effect for some chains, both before and after the merger. Interestingly, sensitivity to competition is elevated after the merger.

We now move on to the cost function estimates (Table 8). Sunkus experiences the largest entry cost, whereas circle K has the largest expansion costs, and Family Mart has the largest contraction cost.  

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24 Having this piece of knowledge allows us to speculate on the possible sources of performance dynamics through demand. For instance, an increase in a retail chain’s size of operation and duration of active operation in a given market might leads to an increase in brand recognition (Pancras, Sriram, and Kumar, 2012; Shen and Xiao, 2014), better knowledge of local demand and thus higher sales per outlet, and improved product quality or scope over time (Basker, Klimek, and Van, 2012; Jovanovic and Rob, 1987).
costs; these costs are roughly 9 million, 9 million, and 7 million Yen, respectively. We see that minimum wage and land price have a negative effect on profits for most of the chains, with the exception of 7-Eleven and LAWSON. One reason for the positive effects of these cost-side variables could be that minimum wage and land price may be tied to the market’s economic growth.

Focusing on the merged firm, increased \( \gamma^C \) and reduced \( \gamma^R \) reveal that unobserved profitability operate heavily through costs for circle K and sunkus after merger. The entry costs and contraction are lower than those of circle K and sunkus as individuals (i.e., before merger). These findings, together with the reduced entry costs after the merger, suggest the presence of savings in the sunk costs of operation and expansion. In other words, the merger had a cost-reducing effect at least partially. Because we observe a decline in the size spillover and retention in the Z process, however, the overall evaluation of the merger needs to rely on a simulation that we develop in the next subsection.

### 5.2 Merger Analysis: Better Together?

Using the estimated model, we now look more closely at the merger between sunkus and circle K. In particular, we simulate trajectories of unobserved profitability over time for sunkus, circle K, and the merged firm. Simulations are necessary because we do not know the exact values of the unobserved profitability, but rather their posterior distributions based on the inferred autoregressive transition equations that govern their evolution.
To illustrate the effect that the merger has on performance dynamics, we plot the unobserved profitability trajectories prior to the merger, as well as the trajectories after the merger, in Figure 4. For example, in 1990, the monetary value of the average unobserved profitability across active markets is around 5 billion Yen (about US$50 million), which amount to 3% of total sales of circle K and sunkus in 1990. We see that by the year 2000, the unobserved profitability level is over 150 billion Yen; however, the level decreases to around 50 billion Yen immediately after the merger, amounting to a 66% drop.

Also noticeable are changes in the growth of unobserved profitability. The thick line “circle K and sunkus (actual)” in Figure 4 reveals that the actual merger led to much slower growth in performance dynamics; for instance, from 2003 onwards, the growth rate for unobserved profitability is virtually zero. This slower growth is largely associated with the merged firm’s diminished ability to retain profitability from the previous period.

**Hypothetical Merger Scenario.** To further investigate the lack of improvements in the growth of unobserved profitability, we consider an exploratory simulation analysis of a hypothetical scenario in which the merged firm combines the two chain brands and inherits the unobserved profitability process of circle K, which is the larger of the two firms. We think of this scenario as one in which the dominant firm, circle K, imposes its tangible and intangible assets, including
corporate culture, and processes onto sunkus, the smaller firm. Such an inheritance of corporate process seems plausible, because we have seen similar integration strategies in other past mergers (e.g., Cisco, General Electric, and Teva).\textsuperscript{25} We proceed by following a similar forward-simulation approach as Benkard, Bodoh-Creed, and Lazarev (2010) and Jeziorski (2014), who also evaluate hypothetical scenarios.

Under this hypothetical scenario, we repeat the same simulation exercise as in the previous section, and plot the trajectory of unobserved profitability in Figure 4, which is the dashed line “circle K only (hypothetical).” The graph illustrates that imposing circle K’s unobserved profitability process onto the merged firm will lead to comparable growth rates in the long-run, despite an initial drop in unobserved profitability immediately following the merger. Even though the pre-merger circle K has smaller size-spillover effects than sunkus, its larger retention effects allow the merged firm to eventually achieve similar trajectories in performance dynamics as prior to the merger.

**Heterogeneity in Profitability across Markets.** We further investigate potential intra-firm heterogeneity in the dynamics of unobserved profitability across various cities for the actual merger case and the hypothetical merger case. For this purpose, we focus on a handful of represen-

\textsuperscript{25}Refer to “Synergy springs from cultural revolution,” *Financial Times*, October 6, 2006, for some anecdotes.
Table 9: Aggregate Comparisons between Actual Merger and Hypothetical Merger Scenarios Five Years after the Merger Event

<table>
<thead>
<tr>
<th></th>
<th>Equilibrium</th>
<th>Hypothetical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of outlets</td>
<td>5482</td>
<td>6578</td>
</tr>
<tr>
<td>Total revenue (in billion Yen)</td>
<td>197</td>
<td>237</td>
</tr>
<tr>
<td>Total profit (in billion Yen)</td>
<td>19</td>
<td>22</td>
</tr>
</tbody>
</table>

Tative markets in Figure 5: two markets from the largest and the third-largest metropolitan areas (Tokyo and Aichi), and two markets from more rural areas (Yamagata and Nagano). These four panels display heterogeneity across markets in how the merger affects performance dynamics. For instance, Yamagata exhibits negative growth in unobserved profitability, reflecting the decreasing number of outlets in that market, whereas in Nagano, the profitability increases over years after merger. Meanwhile, performance dynamics in Tokyo and Aichi exhibit a similar flat profitability following the merger. When the contribution from the size spillover diminishes as the number of outlets decreases, the relative gap between the baseline actual merger case and the hypothetical case (combine everything into circle K), measured by the ratio of actual profitability to profitability in the hypothetical case, the effect of a reduced retention rate is more pronounced. For instance, the profitability in Yamagata for the hypothetical case is 3.48 times larger than the profitability in the actual merger case, whereas the ratio decreases to 2.87 in Nagano. This market-specific heterogeneity in performance dynamics can then provide some guidance regarding markets that may be vulnerable to negative effects from mergers. For example, if a merged chain is reducing the number of outlets in a market, as in Yamagata, the chain suffers more from the reduced retention rate.

Overall, the merged firm’s performance improves in light of this hypothetical merger scenario. Motivated by this finding, we investigate how the improved performance dynamics translate into other aggregated measures, such as the merged firm’s total number of outlets, total revenue, and total profit, five years after the merger in 2006. Table 9 shows that not only do performance dynamics improve in light of the hypothetical merger, but so do store counts, revenue, and overall profits. A comparison between the equilibrium and hypothetical scenarios suggest that imposing circle K’s process onto the merged firm will improve store counts, revenue, and profits by about
6 Conclusion

This paper investigates the role of performance dynamics in the long-run evolution of retail expansion. By combining particle filtering, control functions, and forward simulations, we are able to push the frontier by understanding not only whether such dynamics exist, but the channel through which these dynamics operate. Such an approach is especially applicable when revenue information is available to the researcher. We apply these methodological innovations to a setting involving convenience-store expansion in Japan, which offers us the unique opportunity to look at industry dynamics both before and after an actual merger.

A few key findings emerge. First, our estimates suggest the size-spillover and retention effects both operate through the sunk-cost component of profits. Knowing how these performance dynamics relate to either demand or supply channels further justifies the use of revenue data when analyzing such markets. Second, simulations using the estimated posterior distribution for unobserved profitability and model primitives suggests the merger has a detrimental effect on the underlying unobserved performance dynamics for the merged entities; that is, the joint unobserved profitability for the two firms prior to the merger grows at a higher rate than the unobserved profitability growth after the merger. Finally, exploratory analysis suggests performance dynamics may be preserved (and even improved) if the dominant firm successfully imposes its unobserved profitability process onto the merged firm.

More broadly, although a data limitation prohibited us from further nailing down the specific sources of the unobserved process, our model has shown that employing publicly available data on store counts and sales serves as the first step to investigate how mergers have affected market participants’ unobserved profitability processes. We hope this approach will encourage researchers and practitioners to explore other industries and study effects of mergers on market structure and performance when access to private information, such as inputs, prices, and costs, is limited.

In terms of caveats, our current analysis abstracts away two features of the industry. First, we take the 2001 merger as an exogenous event. Although we believe this assumption is reasonable for this particular industry, because mergers and acquisitions rarely happen in the industry, firms
in general endogenously choose when and with whom to merge. Second, we do not consider the ownership composition of the stores, that is, the fraction of franchised versus corporate-owned outlets. We believe future research in this direction would be fruitful because mergers may have a differential impact on stores, depending on ownership structure. We defer the development of this new framework for future research.
References


Hollenbeck, B. (2013a): “Horizontal Mergers and Innovation in Concentrated Industries,” Manuscript, UCLA.


Appendix A. Seemingly Unrelated Regression (SUR)

We employ an SUR model to capture the dynamics of our exogenous demand- and cost-side variables. Such an approach allows for some potential correlation between the key variables. For example, income and property value often move along similar trends. The SUR specification we use can be described as

\[
\begin{bmatrix}
X_{1t} \\
X_{2t} \\
\vdots \\
X_{kt}
\end{bmatrix} = \begin{bmatrix} c_1 \\
c_2 \\
\vdots \\
c_k \end{bmatrix} + \begin{bmatrix} A_{11} & A_{12} & \cdots & A_{1k} \\
A_{21} & A_{22} & \cdots & A_{2k} \\
\vdots & \vdots & \ddots & \vdots \\
A_{k1} & A_{k2} & \cdots & A_{kk} \end{bmatrix} \begin{bmatrix} X_{1t-1} \\
X_{2t-1} \\
\vdots \\
X_{kt-1} \end{bmatrix} + \begin{bmatrix} e_{1t-1} \\
e_{2t-1} \\
\vdots \\
e_{kt-1} \end{bmatrix},
\]

where \(E[e_t|e_t^c] = \Omega\) and where \(c = (c_1, \ldots, c_k)\), \(A = (a_{ij})\), and \(\Omega\) are parameters to be estimated. The estimated SUR model estimates and covariance matrix are shown in Tables 10 and 11.

Table 10: SUR Model Estimates

<table>
<thead>
<tr>
<th></th>
<th>Population</th>
<th>Income</th>
<th>Minimum Wage</th>
<th>Property Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lagged Population</td>
<td>1.0065</td>
<td>0.0196</td>
<td>-0.0021</td>
<td>7.1895</td>
</tr>
<tr>
<td>Lagged Income</td>
<td>0.0025</td>
<td>0.9266</td>
<td>0.0989</td>
<td>5.4031</td>
</tr>
<tr>
<td>Lagged Minimum Wage</td>
<td>-0.0000</td>
<td>0.0001</td>
<td>-0.0001</td>
<td>0.8886</td>
</tr>
<tr>
<td>Lagged Property Value</td>
<td>-0.0636</td>
<td>-1.9223</td>
<td>0.5645</td>
<td>-246.2148</td>
</tr>
<tr>
<td>Intercept</td>
<td>22.7977</td>
<td>1157.1271</td>
<td>15.9366</td>
<td>127278.0673</td>
</tr>
</tbody>
</table>

Table 11: Estimated SUR Covariance Matrix

<table>
<thead>
<tr>
<th></th>
<th>Population</th>
<th>Income</th>
<th>Minimum Wage</th>
<th>Property Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lagged Population</td>
<td>225.2762</td>
<td>453.0557</td>
<td>-207.6054</td>
<td>71163.0193</td>
</tr>
<tr>
<td>Lagged Income</td>
<td>453.0557</td>
<td>202015.2184</td>
<td>-5083.1525</td>
<td>-1581870.1842</td>
</tr>
<tr>
<td>Lagged Minimum Wage</td>
<td>-207.6054</td>
<td>-5083.1525</td>
<td>10503.9747</td>
<td>1357847.5730</td>
</tr>
<tr>
<td>Lagged Property Value</td>
<td>71163.0193</td>
<td>-1581870.1842</td>
<td>1357847.5730</td>
<td>3791892717.3799</td>
</tr>
</tbody>
</table>

Appendix B. Details about Policy-Function Estimation

We estimate an ordered probit model in which the choice set is \(K_i = K = \{k_1, k_2, \ldots, k_K \}\) with \(k_1 < k_2 < \cdots < k_K\). With an ordered probit, a potential complication arises in terms of the large number of choices each chain has. For example, a chain may expand by adding as many as 127
outlets in a given market and year. To address such issues, we make discrete the actions available, based on the raw distributions of $n_{mt}$, as in Blevins, Khwaja, and Yang (2014). In our application, we choose $K = \{-5, 0, 2, 5, 10, 20, 50\}$. This discretization is chosen based on the most commonly observed expansion decisions we see the retail chains make.

The term $y^*_{imt}$ captures each firm’s latent index, which we use a flexible functional form to capture. Exogenous state variables are summarized as $W_{mt}$ denotes the vector of exogenous state variables that include $X_{mt}$ and relevant interactions between variables. For tractability, we consider a flexible linear specification for $y^*_{imt}$ that includes higher-order terms and interactions:

$$y^*_{imt} = \phi^W \cdot W_{mt} + \phi^Z Z_{imt} + \zeta_{imt}.$$ The serially correlated performance-dynamic measure is captured by $Z_{imt}$, a firm-specific profitability that is based on the specification for the $Z$ process and is integrated out via particle filtering. Finally, we use $\zeta_{imt}$ to denote an independent and normally distributed error term with mean zero and unit variance. Firm and market fixed effects are also included, as per the specified $Z$ process.

The order probit specification is summarized by a collection of threshold-crossing conditions:

$$n_{imt} = \begin{cases} k_1 & \text{if } y^*_{imt} \leq \vartheta_1 \\ k_2 & \text{if } \vartheta_1 \leq y^*_{imt} \leq \vartheta_2 \\ \vdots & \vdots \\ k_K & \text{if } \vartheta_{K-1} \leq y^*_{imt} \leq \vartheta_K \end{cases}.$$ The values $\vartheta_1, \ldots, \vartheta_K$ are the $K$ cutoff parameters corresponding to each outcome. These cutoffs are estimated using sieve maximum likelihood along with the index coefficients, and the parameters in the law of motion for $Z_{imt}$.

### Appendix C. Revenue-Function Estimation

To obtain $\hat{Z}_{imt}$, we first simulate many trajectories for each market-time. We then obtain the average value of the simulated posteriors to obtain $\hat{Z}_{imt}$. Similarly, $\hat{n}_{imt}$ is the average number of
outlets across simulations for a given market and time. With the estimated parameters, we proceed to the final step. Ellickson and Misra (2012) point out that the private-information assumption regarding $\zeta_{int}$ helps us simplify the problem greatly, because this assumption allows us to decompose the joint selectivity problem into a collection of individual (firm-specific) selectivity problems. For the control-function specification, we choose a simple third-order polynomial, which is a flexible non-linear function of the predicted number of added or subtracted outlets $\hat{n}_{int}$:

$$\Lambda(\hat{n}_{int}) = \varphi_1 \hat{n}_{int} + \varphi_2 \hat{n}_{int}^2 + \varphi_3 \hat{n}_{int}^3.$$  

We run different revenue regressions depending on whether the policy functions are pre-merger or post-merger. Having separate revenue regressions seems appropriate, because the underlying selection issues that the control function approach is meant to address may be systematically different before and after the merger.

**Appendix D. Incorporating the Merger Event**

Our estimation makes use of the pre- and post-merger states. Before the merger, we use the actual $N_{int}$ in the first-stage policy-function estimation for sunkus and circle K. After the merger, we set $N_{int} = 0$ for sunkus and circle K, and make use of the actual $N_{int}$ for the merged entity called C&S in the first-stage policy-function estimation. In the forward-simulation stage, we take into account the merger by computing the discounted profit streams based on whether sunkus and circle K have merged.

Our analysis relies on the assumption that when the firms are employing a pre-merger equilibrium strategy, they are not anticipating a merger event well in advance. For example, one or both of the companies may have an incentive to adjust their expansion/sales strategies as a means to make themselves more attractive as merger targets. To check that pre-merger equilibrium behavior

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26 We do not run revenue regressions for each possible alternative of $n_{int}$, but instead use the predicted number $\hat{n}_{int}$ via forward simulations as a sufficient statistic. The main reason we make this simplification is to avoid the curse of dimensionality associated with many multinomial choice problems. For example, if there are 8 expansion/contraction options a firm can make as to how many stores to subtract or add, and if we used a second order polynomial approximation for the control function, we would have to estimate 32 parameters alone for the selectivity correction component alone.
is not erratic leading up to the merger, we plot the trajectory of store counts and total revenues in Figures 2 and 3. From the graphs, we see that the expansion and sales growth in the 10 years prior to 2001 do not appear to be volatile; that is, they follow a fairly linear growth rate leading up to the merger. After the merger in 2001, we do see a change in the growth rate for store counts and total sales, but our analysis explicitly takes this change into account because we are estimating policy functions separately before and after the merger.