Entry by Merger:
Estimates from a Two-Sided Matching Model with Externalities*

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Abstract

As firms often acquire incumbents to enter a new market, presence of desirable acquisition targets affect both merger and entry decisions simultaneously. We study these decisions jointly by considering a two-sided matching model with externalities to account for the “with whom” decision of merger and to incorporate negative externalities of post-entry competition. By estimating this model using data on commercial banks, we investigate the effect of the state-level entry deregulation. After proposing a deferred acceptance algorithm applicable to the environment with externalities, we exploit the lattice structure of stable allocations to construct moment inequalities that partially identify the banks’ payoff function including potential (dis)synergies. We find greater synergies between larger and healthier potential entrants and smaller and less-healthy incumbent banks. Compared with de novo entry, entry barriers are much lower for entry by merger. By prohibiting de novo entry, our counterfactual quantifies the effect of the deregulation.

Keywords: Entry, merger, two-sided matching, partial identification

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1 Introduction

Firms often use mergers and acquisitions to enter new markets.\(^1\) In such cases, presence of desirable acquisition targets affects not only merger decisions but also entry decisions at the same time. For example, a firm may choose not to enter a market if it cannot find a good target incumbent for acquisition. In some markets, entry barriers for \textit{de novo} entry can be so high that acquiring an incumbent may be the only profitable way to enter. Thus, entry and merger decisions are joint decisions, and should not be separately studied in those markets. Moreover, as entry by merger impacts the competitive structure of markets, studying entry by merger may have important policy implications.\(^2\)

In this paper, we study entry and merger decisions jointly in the U.S. commercial banking industry where entry by merger is prevalent. In particular, we investigate the effect of the state-level entry regulation. We focus on 7 states that deregulated the \textit{intra-state} de novo entry restriction during the period between 1995 and 2000. Using data on bank behavior in the regional markets of these 7 states for the period right after the deregulation, we study how the entry regulation affected entry and merger decisions.

To study the banks’ behavior, we consider a model in which the “with whom” decision of the merger and the post-entry (and post-merger) competition are addressed simultaneously. We do so by combining a standard entry model (Bresnahan and Reiss, 1991, and Berry, 1992) with a two-sided matching model with contracts (Hatfield and Milgrom, 2005). For the “with whom” decision, two features are particularly important: i) the payoff from merger depends on potential (dis)synergy, which significantly differs across pairs of firms (we specify a \textit{synergy function} to quantify potential (dis)synergies), and ii) the merger decision is not a unilateral one because the target firm must agree to the merger contract. Reflecting these features, we adopt a matching model. Specifically, we consider a one-to-one two-sided matching model in which firms are partitioned into two sides, incumbents (\(I\)) and potential entrants (\(E\)), because the vast majority of the mergers in our data are mergers between one incumbent and one potential entrant.\(^3\)

\(^1\)A significant fraction of market entry is reported to be by merger. Yip (1982) reported that more than one-third of entries in 31 product markets in the United States over the period 1972-1979 were by acquisition. Among 558 market entries into the United States by Japanese companies during 1981-1989, Hennart and Park (1993) found that entry by merger accounted for more than 36%.

\(^2\)Entry by merger has been an important antitrust issue. The Federal Trade Commission (FTC) explicitly considers “potential new competitors” in its Merger Guidelines. A classic case is the FTC’s decline of a merger attempt by Procter & Gamble (P&G) and the Clorox Corporation in 1967. FTC argued that P&G was the most likely potential entrant in the household bleach industry, and that P&G’s acquisition of Clorox would eliminate P&G as a potential competitor, which would substantially reduce the competitiveness of the industry.

\(^3\)This fact reflects the types of market we observe: our data is from small regional markets where average number of incumbents are less than 5 (see Section 3 for the detail), thus mergers between incumbents or mergers involving more than two incumbents tend to be infeasible due to antitrust concerns.
Regarding how we incorporate the effect of post-entry competition into the matching model, we follow a standard entry model (Bresnahan and Reiss, 1991, and Berry, 1992) in which the effect of competition on profit is modeled as a decreasing function of the number of operating firms. A firm considers this effect of competition on profit (negative externalities), and chooses the best option out of the three types of options \{Enter with merger, Enter without merger, Do not enter\}.\(^4\) Because the profit of a firm depends not only on the firm’s matching (merger partner) but also on the merger and entry decisions of other firms (e.g., whether another incumbent is acquired by a potential entrant), the model we consider becomes a two-sided matching model with externalities.

Considering externalities in a matching model is not straightforward (see, e.g., Sasaki and Toda, 1996, and Hafalir, 2008). This is because, with externalities, payoffs depend not only on matching but also on the entire assignment of who match with whom. The solution concept in such a case thus has to take into consideration, for each deviation, what the entire assignment would be in addition to with whom the deviating players would match. To incorporate what the assignment would be after each deviation, Sasaki and Toda (1996) and Hafalir (2008) propose an estimation function that maps each deviation to an expectation about the possible assignments following the deviation. Despite taking this approach, the model with general form of externalities is complex and the existence of a stable matching requires strong conditions. In our case, however, complexities are reduced by the fact that the externalities take a particular form — it depends only on the aggregate number of operating firms negatively (i.e., negative network externalities). Hence, we can modify the estimation function approach so that the estimation is only about the aggregate number of operating firms. More specifically, we use “myopic estimation function” as is commonly used in the literature (e.g., Baccara et al., 2012).

Estimating a two-sided matching model posits an econometric challenge: the model typically has multiple equilibria and the parameter cannot be point-identified without imposing an equilibrium selection rule. Instead of imposing equilibrium selection mechanism, we adopt the partial-identification approach. We propose a novel estimation approach that can be applied to many of two-sided matching models with non-transferable utility in general. In particular, we exploit the lattice structure of the set of equilibria. Though the econometrician cannot tell the equilibrium selection rule in the observed data, the lattice property provides upper and lower bounds for the equilibrium payoffs for each firm. To be more precise, all incumbents have the highest equilibrium payoff in incumbent(\(I\))-optimal equilibrium, and the lowest equilibrium payoff in potential entrant(\(E\))-optimal equilibrium.

\(^4\)As we consider a matching model, the first option requires the consent of the matching partner for the matching to be stable, while the last two options can be chosen unilaterally (See Section 2.2.2 for more detail). Our model differs from a standard two-sided matching model in that there are two outside options, i.e., firms can be unmatched in two ways by either entering without merger or by not entering the market.
All other equilibrium payoffs are bounded by these two equilibrium payoffs. Hence, the payoff corresponding to the observed outcome is bounded above and below by these extremal equilibrium payoffs, from which we construct moment inequalities for incumbents. Similarly, all potential entrants obtain the highest payoff in $\mathcal{E}$-optimal equilibrium and so on. Thus, we can construct moment inequalities using these equilibrium characterizations without the knowledge of the equilibrium selection rule.

The identified set can be reduced further by considering other equilibrium properties on top of the moment inequalities in payoffs. In all equilibria, the model predicts that the identity of the firms that enter without merger (the result is analogous to the *lone wolf theorem* and the *rural hospitals theorem*. See, e.g., Roth, 1986, and Hatfield and Milgrom, 2005). This implies that the payoff of the firms entering without merger is the same across all equilibrium. Using this property, we construct moment equalities on the payoff for firms entering without merger in addition to the moment inequalities on payoffs for firms entering with merger.

Based on the moment equalities and inequalities discussed above, we estimate the model using Andrews and Soares’s (2010) generalized moment selection. In computing the sample analogue of the moments, we run a version of the generalized Gale-Shapley algorithm in order to obtain both $I$-optimal and $\mathcal{E}$-optimal equilibria for each simulation draw for each market.

We find a significant difference in entry barriers for incumbents, potential entrants, and entry by merger. The entry barrier for potential entrants is much higher than that of the incumbents as well as that of entry by merger, causing a significant fraction of entry by potential entrants to take the form of merger and acquisition. Concerning the (dis)synergies from mergers between different types of firms, bank characteristics affect (dis)synergy differently across the sides of incumbents and potential entrants. We find that synergy between potential entrants with a larger asset size and higher equity ratio and incumbents with a lower equity ratio tends to be much higher. This may reflect the pattern in the data that large and healthy banks enter new markets by buying incumbents with less-healthy balance sheets.

Finally, we conduct a counterfactual policy experiment to assess the effect of the entry regulation. We find the number of banks operating in a market would have decreased if de novo entry by potential entrants had not been deregulated by the deregulation. Prohibition of de novo entry provides stronger incentive to enter by merger for potential entrants, and accordingly we find that the number of entry by merger increases if de novo entry were prohibited.

In the rest of the paper, we present a two-sided matching model in Section 2 after discussing the related literature in Section 1.1. All proofs for Section 2 are in Appendix
A. We document the data in Section 3, and then provide the econometric specification, identification, and estimation procedure in Section 4. Section 5 reports the results of the estimation and the counterfactual experiment. Finally, we conclude in Section 6.

1.1 Related Literature

Our paper adds to several strands of literature. The first strand of the related literature is the literature on estimating matching models. We add to this literature by proposing a new approach to estimate a matching model with non-transferrable utility.\(^5\) Only a few papers estimate matching models with non-transferrable utility. Gordon and Knight (2009) consider merger of school districts, and their specification on match quality is similar to our synergy function, though they consider a one-sided matching model (roommate problem). Also their paper is close to ours as they run an algorithm to find a stable matching in their estimation. Sorensen (2007) studies the matching between venture capitalists and entrepreneurs, and estimates the model under the assumption that players have aligned preferences. Boyd et al. (forthcoming) similarly estimate a two-sided matching model between teachers and schools by running the Gale-Shapley algorithm with the assumption that the school-optimal stable matching is realized. Similarly with a known equilibrium selection mechanism, Uetake and Watanabe (2012) propose another estimation strategy for a two-sided matching model with non-transferable utility using Adachi’s (2000) prematching mapping. In environments with only aggregate-level data available, Echenique, Lee, Shum, and Yenmez (forthcoming) study testable implications of stable matchings. In a similar environment, Hsieh (2011) proposes a modified deferred acceptance algorithm to study identification and estimation. These two papers differ from ours as they consider aggregate-level data while we use individual-level data. Our paper also differs from these papers in that we consider matching with contracts. Finally, a number of papers estimate matching models with transferrable utility.\(^6\) Among these, Akkus and Hortaçsu (2007) and Park (2011) are close to ours in that they study the merger of banks and mutual funds, respectively. Our paper adds to these papers by explicitly considering the effect of post-merger competition.

The second strand of the related literature is the large and growing theoretical literature on matching.\(^7\) Our paper builds on Hatfield and Milgrom (2005, hereafter denoted as HM), who study a matching model with contract. In fact, our solution is derived using the HM’s generalized Gale-Shapley algorithm given the myopic estimation function. HM characterize the set of stable allocations for the matching model with contract, and show that the set of

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\(^5\) Although there is a transfer, our model is a model with non-transferrable utility. This is because we allow players to have some components which are not transferable.

\(^6\) See, e.g., Choo and Siow (2006), Fox (2010), Galichon and Salanié (2010), Bacarra et al. (2012), and Chiappori, Salanié, and Weiss (2010).

\(^7\) See, e.g., a survey by Roth (2008).
stable allocations in two-sided matching with contracts has lattice property and proves the existence using Tarski’s fixed-point theorem.\textsuperscript{8} We follow their approach and incorporate two additional features; we allow externalities and participation decisions. In matching models, a player’s individual rationality condition is about whether he has incentive to be matched with others, but not about his participation to the matching market. We explicitly consider the incentive to “participate,” and make the preference dependent on the number of “participants,” which is the externalities we consider.

To the best of our knowledge, Sasaki and Toda (1996) and Hafalir (2008) are the closest papers that investigate a two-sided matching model with externalities.\textsuperscript{9} Both papers consider a very general form of externalities. Analyzing such matching models is difficult because preference is defined over the set of assignments rather than matchings. Hence, regular definition of “stability” or “deviation” are not sufficient to analyze such a model because a deviating pair’s preference also depends on how other agents would react to their deviation, not just their matching. To model how other agents would react to a player’s deviation, both papers use what they call the estimation function approach. Estimation functions specify the expectations on the assignment (i.e., what the matching among all players would be) after each deviation. They prove that a strong requirement on the estimation function is necessary in order to guarantee the existence of stable matching. Instead of requiring strong assumptions on estimation functions, we use “myopic estimation function” following more recent studies such as Baccara et al., for tractability of the model.

The third strand of the literature is the literature on estimating entry models following Bresnahan and Reiss (1991) and Berry (1992), where the firms’ underlying profit functions are inferred from the observed entry decisions.\textsuperscript{10} We add to this literature by examining the entry and merger decisions jointly. We do so by combining two-sided matching model with the entry model. Our approach is similar to Ciliberto and Tamer (2009) in using a set estimator to address multiplicity of equilibria. Also, our identification argument builds on their identification results. Other related studies include Jia (2008) and Nishida (2012) that characterize the equilibrium of an entry model with correlated markets as a fixed point in lattice and solve for it to estimate the model. Our paper differs from theirs in that ours make no equilibrium selection assumption and construct moment inequalities exploiting the lattice properties.

Among papers in entry literature, Perez-Saiz (2013) is closest paper to ours in terms

\footnotesize{\textsuperscript{8}See also Adachi (2000), Echenique and Oviedo (2006), and Ostrovsky (2008) for characterizations of the set of stable matchings using similar techniques in various matching environments.}

\footnotesize{\textsuperscript{9}Other papers investigating two-sided matching model with externalities include Baccara et al. (2012), Muncu and Saglan (2010), Bando (2012) and Brânzei et al. (2012). Baccara et al. (2012) considers an empirical application for office assignment, while the other three papers are theoretical work looking into the existence and characterization of the stable matching.}

\footnotesize{\textsuperscript{10}Other recent contributions include Mazzeo (2002) and Seim (2006).}
of research question. He models firm’s decision as a three stage extensive form game, and estimate it using the data of the U.S. cement industry. After choosing whether to enter by merger, enter without merger, or not entering, firms entering with merger engages in bidding for merger contracts, active firms play a Cournot game in the third stage. In his model, merger decisions are conditional on entry decisions, while these decisions are simultaneous in our model. He finds that ignoring the possibility of entry by merger significantly overestimates the entry cost.

The fourth strand is the literature on horizontal merger decisions. In spite of the large literature considering the effects of mergers, studies on the endogenous horizontal merger decision itself are limited.\footnote{There are also a few papers that study the relationship between merger decisions and merger review policy. See, e.g., Nocke and Whinston (2010).} Kamien and Zang (1990) show limits to monopolization through mergers, and Qiu and Zhou (2007) point out the importance of firm heterogeneity in horizontal mergers. Gowrisankaran (1999) develops a computable dynamic industry competition model with an endogenous merger decision. Pesendorfer (2005) finds the relationship between market concentration and the profitability of mergers using a repeated game with merger decision. In a model with de novo foreign direct investment and cross-border merger and acquisitions, Nocke and Yeaple (2007) show the importance of firm heterogeneity as key determinants. Our paper adds to this literature by empirically investigating the role of firm heterogeneity in merger decisions.

Finally, our paper is also related to the literature studying banks’ branching decisions. Ruffer and Holcomb (2001) use data from California and investigate the determinants of a bank’s expansion decision by building a new branch and acquiring an existing branch, respectively. Their results show that a large bank would be likely to enter a new market by acquisition, but not through building a new branch, which is consistent with our result that larger potential entrants have higher synergy ceteris paribus. Wheelock and Wilson (2000) study the determinants of bank failures and acquisitions using a competing-risks model. Consistent with our finding, they show that less capitalized banks are more likely to be acquired for the period between 1984 and 1993. Cohen and Mazzeo (2007) estimate an entry model with vertical differentiation among retail depository institutions, and find evidence of product differentiation depending on market geography.

2 Model

We model the entry and merger decisions as a two-sided matching problem with externalities. We build the model combining models of entry (Bresnahan and Reiss, 1991, and Berry, 1992) and two-sided matching with contracts (Hatfield and Milgrom, 2005). Then, we pro-
vide characterizations of the stable outcomes: the set of stable outcomes forms a complete lattice, and the two extremal points of the set can be obtained by running a deferred acceptance algorithm that we propose. We use these characterizations for partial-identification and estimation of the model.

2.1 A Matching Model of Entry and Merger

We consider a static entry model in which firms can use merger and acquisition as a form of entry in addition to regular entry without merger. In particular we integrate entry and merger decisions into a two-sided matching model between an incumbent firm (denoted by \( i \in \{1, \ldots, N_I\} \equiv \mathcal{I} \)) and a potential entrant (denoted by \( e \in \{1, \ldots, N_E\} \equiv \mathcal{E} \)). The model is a static one and being an incumbent is simply a characteristic of a firm. In other words, being an incumbent does not have particular dynamic implications. Note that we abstract from mergers between incumbents as well as mergers involving more than three firms.

We adopt a two-sided matching model because mutual consent between the two parties is required for a merger. In particular, we consider one-to-one two-sided matching instead of coalition formation, one-to-many matching, or many-to-many matching for the reason that the vast majority of mergers in our data are one-to-one mergers between an incumbent and a potential entrant.\(^{12}\) This fact reflects the types of market we observe: our data is from small regional markets where average number of incumbents are less than 5 (see Section 3 for the detail), thus mergers between incumbents or mergers involving more than two incumbents tend to be infeasible due to antitrust concerns. Finally, we consider a matching model instead of a specific extensive form game because the details about individual merger process (such as how investment banks and FDIC are involved in each case, how both sides negotiate the merger contract, etc.) are not observable in general.

Our matching model adds two features to a regular two-sided one-to-one matching model with contracts by i) considering two outside options (the decisions of “enter without merger” and “not to enter”), and ii) incorporating externalities that depend on the number of operating firms (network externalities).

Firms on both sides have three types of choices. Potential entrant \( e \) can choose not to enter (denoted by \( \{o\} \)), enter by itself (denoted by \( \{e\} \)), or merge with incumbent \( i \) with a merger contract \( k_{ei} \) (denoted by \( \{k_{ei}\} \)). Merger contracts are bilateral ones between a potential entrant and an incumbent, and each firm can sign only one merger contract with a firm on the other side. A contract \( k_{ei} = (e, i, p_{ei}) \) specifies a potential entrant and an

\(^{12}\)One can also think about a dynamic matching model in which agents consider matching each period in stead of static matching. We choose not to model dynamics as dynamic issues such as merger waves are limited in our data. Also, theoretical characterization of dynamic matching models is not much known, and computational cost of such models would be extremely high.
incumbent pair and the terms of the merger, \( p_{ei} \in P \), where the set of merger terms \( P \) is finite as in HM.

Similarly to potential entrants, incumbent \( i \) has three types of choices: it can choose not to enter (denoted by \( \{o\} \)), enter by itself (denoted by \( \{i\} \)), or merge with potential entrant \( e \) with a merger contract \( k_{ei} \) (denoted by \( \{k_{ei}\} \)).

We denote the set of merger contracts by \( K \equiv E \times I \times P \). Note that the set of merger contracts does not include the case where a potential entrant or incumbent does not enter the market or the case where they enter by themselves. Let the set of merger contracts in which entrant \( e \) is involved be \( K_e \) and in which incumbent \( i \) is involved be \( K_i \), i.e.,

\[
K_e = \bigcup_{i \in I} \{k_{ei}\}, \quad \text{and} \quad K_i = \bigcup_{e \in E} \{k_{ei}\}.
\]

We also define the set of available choices for \( e \) and \( i \) as

\[
\bar{K}_e = K_e \cup \{e\} \cup \{o\} \quad \text{and} \quad \bar{K}_i = K_i \cup \{i\} \cup \{o\}.
\]

For simplifying the notation, we define \( \bar{K} = \bigcup_{j \in E \cup I} \bar{K}_j \).

Payoffs depend on the outcome of the matching game. Because we consider entry and merger decisions after which firms compete, a firm’s payoff is affected not only by its entry and merger decisions (matchings) but also by other firms’ entry and merger decisions (assignments). Hence, we need to consider a model with externalities due to post-entry competition. Also, non-monetary components such as a manager’s idiosyncratic taste over the potential merger may play an important role in the actual merger decisions (e.g., Malmendier and Tate, 2008). Thus, we allow the payoff of a firm to depend not only on the profit but also on other factors. We denote the payoff of incumbent \( i \) as

\[
U_i(k_{ei}, k_{-i}) = u_i(\pi_i(k_{ei}, k_{-i})) + \varepsilon_{ei} \quad \text{if firm } i \text{ merges with firm } e \text{ with contract } k_{ei},

U_i(i, k_{-i}) = u_i(\pi_i(i, k_{-i})) + \varepsilon_{ii} \quad \text{if firm } i \text{ enters without merger},

U_i(o, k_{-i}) = 0 \quad \text{if firm } i \text{ does not enter},
\]

where \( \pi_i(\cdot, k_{-i}) \) is the monetary profit with other firms choosing \( k_{-i} \), \( u_i(\cdot) \) is a monotonically-increasing payoff function, and \( \varepsilon_{ei} \) and \( \varepsilon_{ii} \) are non-pecuniary idiosyncratic shocks. As we assume \( \varepsilon_{ei} \) and \( \varepsilon_{ee} \) to be continuously distributed, the preferences are strict generically.

In the same way, we can write potential entrant \( e \)'s payoff as

\[
U_e(k_{ei}, k_{-e}) = u_e(\pi_e(k_{ei}, k_{-e})) + \varepsilon_{ei} \quad \text{if firm } e \text{ merges with firm } i \text{ with contract } k_{ei},

U_e(e, k_{-e}) = u_e(\pi_e(e, k_{-e})) + \varepsilon_{ee} \quad \text{if firm } e \text{ enters without merger},

U_e(o, k_{-e}) = 0 \quad \text{if firm } e \text{ does not enter},
\]
where $\pi_e(\cdot, k_{-e})$ is the monetary profit with other firms choosing $k_{-e}$, $u_i(\cdot)$ is a payoff function, $\varepsilon_{ei} (\neq \varepsilon_{ie})$ and $\varepsilon_{ee}$ are non-pecuniary idiosyncratic shocks. We do not impose $\varepsilon_{ei} = \varepsilon_{ie}$ since acquiring and target firms may have heterogeneous preferences on the potential merger.

We consider both the non-pecuniary shocks, $\varepsilon_{ei}, \varepsilon_{ee}, \varepsilon_{ie}$ and $\varepsilon_{ii}$, and payoff from monetary profit, $u_e(\pi_e)$, reflecting the fact that factors not directly measured by monetary profit may have varying importance across firms in merger and entry decisions. Such differences may result from variations in the degree to which managerial and shareholder interests are misaligned as in Jensen and Meckling (1976). Other sources could be differences in CEOs’ overconfidence on merger decisions (Malmendier and Tate, 2008) and variations in manager’s strategic ability on entry decisions (Goldfarb and Xiao, 2011).

To write the profit functions, let us first define $n(\cdot, \cdot)$, which is the number of operating firms given firm $i$’s choice $k_i$ and other firms choices $k_{-i}$ as

$$n(k_i, k_{-i}) = \frac{1}{2} \left[ N_{all} - \sum_{j \in \mathcal{E} \cup \mathcal{I}} 1\{k_j = o\} + \sum_{j \in \mathcal{E} \cup \mathcal{I}} 1\{k_j = j\} \right],$$

where $N_{all} = N_E + N_I$. We then write the specification of the profit function for incumbent $i$ (for entry without merger and no entry) as

$$\pi_i(i, k_{-i}) = \alpha n(i, k_{-i}) + z_0 + x_i \beta_{1i} + \beta_{2i} + \xi,$$

$$\pi_i(o, k_{-i}) = 0,$$

where $\alpha < 0$ is the degree of the negative externalities due to competition. $z_0$ denotes market characteristics, $\kappa_i$ denotes the characteristics of firm $i$, and $\beta_0$ and $\beta_{1i}$ denote the effects of these characteristics on profits. $\beta_{2i}$ is a constant term for incumbents entering without merger. The last term, $\xi$, denotes market-level profit shock, which follows a distribution independently. If the firm does not enter the market, the profit is zero. Similarly, we write the profit function for entrant $e$ (for entry without merger and no entry) as

$$\pi_e(e, k_{-e}) = \alpha n(e, k_{-e}) + z_0 + x_e \beta_{1E} + \beta_{2E} + \xi,$$

$$\pi_e(o, k_{-e}) = 0,$$

where $x_e$ denotes firm $e$’s characteristics, and $\beta_{2E}$ is a constant term for potential entrants, which we allow to differ from $\beta_{2i}$ for incumbents.

Next, in order to write the profit for the case of entry with merger, we start with the profit of the merged entity. We write the profit of the merged entity to depend on negative externality of competition, market characteristics, and market-level shock in the
same way as entry without merger. We also have another term, \( f(x_i, x_e, x_{ie}) \), which we call as (dis)synergy function, in order to capture the (dis)synergies generated given the characteristics of both firms \((x_i \text{ and } x_e)\) and the merger-specific characteristics, \(x_{ie}\). The profit after merger between firms \(e\) and \(i\) given the (dis)synergy function \(f\) and the number of operating firms is written as

\[
\pi(k_{ei}, k_{-i}) = \alpha n(k_{ei}, k_{-i}) + z\beta_0 + f(x_i, x_e, x_{ie}) + \xi,
\]

\[
f(x_i, x_e, x_{ie}) = \beta_{2M} + x_i\beta_3 + x_e\beta_4 + x_i x_e \beta_5 + x_{ie}\beta_6,
\]

where \(\beta_{2M}\) is a constant term for (dis)synergy, \(\beta_3\) and \(\beta_4\) are the effects of the incumbent’s and potential entrant’s characteristics on (dis)synergy of the merger, respectively, and \(\beta_5\) captures the effect of the interaction terms of both firms’ characteristics on (dis)synergy. \(\beta_6\) measures how the match-specific characteristics affect the (dis)synergies.

Because the terms of merger contracts take cash and stock as medium of payment, we consider the space of the term of trade \(P\) as \(P = T \times R\), where \(T = \{t_1, ..., 0, ..., t\}\) corresponds to a finite set of cash transfers, and \(R = \{0, ..., 1\}\) corresponds to a finite set of stock shares between \(e\) and \(i\) after merger. Now we can write the profit function for the case of mergers with contract \(k_{ei}\) for firms \(e\) and \(i\) as

\[
\pi_e(k_{ei}, k_{-e}) = r_{ei}\pi(k_{ei}, k_{-e}) - t_{ei},
\]

\[
\pi_i(k_{ei}, k_{-i}) = (1 - r_{ei})\pi(k_{ei}, k_{-i}) + t_{ei},
\]

where \(t_{ei} \in T\) denotes a cash transfer from \(e\) to \(i\) and \(r_{ei} \in R\) denotes a payment in stock shares of the merged entity from \(e\) to \(i\).\(^{13}\) Note that both \(r_{ei}\) and \(t_{ei}\) are observable for the realized merger contracts as data.

Though we write payoff of \(j\) as a function of \(k_j\) and \(k_{-j}\), it affects payoff only through the number of operating firms \(n(k_j, k_{-j})\). By denoting \(N = n(k_j, k_{-j})\), we abuse notation as \(U_j(k_j, N) = U_j(k_j, k_{-j})\) when our argument is about the degree of externality.

### 2.2 Stable Outcome

Considering externalities in a two-sided matching model is difficult in general (Sasaki and Toda, 1996, Hafalir, 2008). This is because preference is dependent not only on one’s own matching (as in the case without externalities), but also on how other players are matched with each other (i.e., the entire assignment).\(^{14}\) In order to describe the way each player

\(^{13}\) Set \(T\) can include negative values for the cases where \(i\) acquires \(e\).

\(^{14}\) In a matching model with externalities, if a pair of players deviates (dissolves the match), each member of the pair has to think not only about their own matching but also about how other players (including his/her previous partner) are reacting to the deviation because preferences are defined over assignment rather than
expects how other players are matched with each other, we follow Sasaki and Toda (1996) and Hafalir (2008) to use the estimation function approach. In fact, they show that even guaranteeing existence under “rational” estimation function is very difficult. Hence, we make two modifications in our setup.

First, we restrict our attention to myopic estimation function for technical tractability as in other papers in the literature (e.g., Sasaki and Toda, 1986; Baccara et al., 2012; Mumcu and Saglan, 2010; and Bando, 2012). Estimation about other players’ behavior is assumed to be fixed under this assumption as strategies in Nash equilibrium are. Second, we define the estimation function as a mapping from the set of choices to the set of estimated number of operating firms (instead of the set of entire assignment), i.e., \( N_j : K_j \rightarrow \mathbb{R}_+ \). This reflects the fact that in our environment only the number of operating firms in the market affects payoffs instead of the entire assignment.\(^{15}\)

Now we describe the choice by firms given the estimation function. In order to represent the choice by a potential entrant given the set of available merger contracts \( K_e \) and the estimation function \( N_e \), we define the chosen set from merger contracts \( C_e(K_e, N_e) \) for \( e \) as the following:

\[
C_e(K_e, N_e) = \begin{cases} \emptyset & \text{if } \{ k \in K_e | \text{argmax}_{k \in K_e} \{ U_e(k, N_e) \} \} = \emptyset, \\
\text{argmax}_{k \in K_e} \{ U_e(k, N_e) \} & \text{otherwise,}
\end{cases}
\]

where \( U_e(k, N_e) \equiv U_e(k, N_e(k)) \) by suppressing \( k \) from \( N_e(k) \). This set is the best available merger contract given the available set of contracts \( K_e \), which can be a null set if no merger contract is more attractive than de novo entry and no entry. Similarly, we define the chosen set from merger contracts for incumbent \( i \) given the available set of contracts \( K_i \) as follows:

\[
C_i(K_i, N_i) = \begin{cases} \emptyset & \text{if } \{ k \in K_i | \text{argmax}_{k \in K_i} \{ U_i(k, N_i) \} \} = \emptyset, \\
\text{argmax}_{k \in K_i} \{ U_i(k, N_i) \} & \text{otherwise,}
\end{cases}
\]

which also can be a null set if no merger contract is more attractive than de novo entry and no entry.

matching. To illustrate this point, suppose Players A and X are currently matched. If Player A deviates to form a blocking pair with Player Y, Player A has to consider not only that Player Y has incentive to be matched with A, but also what other players, including Player X, would do after the deviation, because the entire outcome (rather than just whom Player A is matched with) affects Player A. Thus, Player A’s expectations about the possible entire outcomes after the deviation are crucial.

\(^{15}\)This assumption can be relaxed in some dimensions such as the case that the firms are vertically differentiated as in Mazzeo (2002). Suppose each firm has its type based on some observable firm specific characteristics such as high, medium, and low quality or for- and non-profit. Denote the number of total operating firms for each type by \( N_s, s = 1, 2, \ldots, S \). Then, the payoff can depend on the total number of operating firms for each type: \( \pi_j(\{k\}, (N_s)_{s=1}^{S}) \), and similar analysis can be extended. In fact, we estimate the model with this specification (“type” is based on asset size) in addition to the base model without vertical differentiation. We present the results in Section 5.
In addition to the chosen set from merger contracts, we also need to track the choices of firms including no entry and entry without merger. We denote the chosen set for incumbent \( i \) by \( \mathcal{C}_i(\mathcal{K}_i, \mathcal{N}_i) \) and for potential entrant \( e \) by \( \mathcal{C}_e(\mathcal{K}_e, \mathcal{N}_e) \), which is either the most preferred merger contract available to firm \( j \) in \( \mathcal{K}_j \), entry without merger, or no entry, i.e.,

\[
\mathcal{C}_i(\mathcal{K}_i, \mathcal{N}_i) = \text{argmax}_{k \in \mathcal{K}_i} \{ U_i(k, \mathcal{N}_i) \}, \\
\mathcal{C}_e(\mathcal{K}_e, \mathcal{N}_e) = \text{argmax}_{k \in \mathcal{K}_e} \{ U_e(k, \mathcal{N}_e) \}.
\]

The difference between the chosen set from merger contracts and the chosen set is the following. \( \mathcal{C}_i(\mathcal{K}_i, \mathcal{N}_i) \) and \( \mathcal{C}_e(\mathcal{K}_e, \mathcal{N}_e) \) take the null set if no entry or entry without merger is preferred to any merger contract in \( \mathcal{K}_j \), while \( \mathcal{C}_i(\mathcal{K}_i, \mathcal{N}_i) \) and \( \mathcal{C}_e(\mathcal{K}_e, \mathcal{N}_e) \) will never be a null set. This is because \( \mathcal{C}_i(\mathcal{K}_i, \mathcal{N}_i) \) and \( \mathcal{C}_e(\mathcal{K}_e, \mathcal{N}_e) \) specify the optimal choice among \( \mathcal{K}_j \) for each player, which may include no entry or entry without merger.

Now, we define stability as our solution concept. Before defining stability, let us define the set of all merger contracts included in the set of outcomes \( \mathcal{K} \) by \( \mathcal{K} = \bigcup_{j \in \mathcal{E} \cup \mathcal{I}} \mathcal{K}_j \backslash \{\{o\} \cup \{j\}\} \).

**Definition 1 (Stability)** A set of available choices and estimation functions \( (\mathcal{K}^*, \mathcal{N}^*) \) is a stable outcome if

1. (Individual rationality) \( \forall j \in \mathcal{E} \cup \mathcal{I}, \exists \bar{k} \in \mathcal{K}_j \) s.t.

\[
U_j(\bar{k}, \mathcal{N}_j^*) \geq U_j(\mathcal{C}_j(\mathcal{K}_j^*, \mathcal{N}_j^*), \mathcal{N}_j^*).
\]

2. (No blocking contracts) \( \exists \bar{k} \in \mathcal{K} \) s.t. \( \bar{k} \neq K \) and

\[
\bar{k} = \bigcup_{j \in \mathcal{I}} C_i(\mathcal{K}_j^* \cup \bar{k}, \mathcal{N}_j^*) = \bigcup_{e \in \mathcal{E}} C_e(\mathcal{K}_j^* \cup \bar{k}, \mathcal{N}_e^*).
\]

A few comments are in order. First, we slightly modify the standard definition of stability as we allow two outside options: entry without merger and no entry. In the standard definition of individual rationality for matching models, players compare being unmatched to matching with someone. In such cases players can unilaterally choose to stay in the market alone. In our case, the players choose one of the better outside options if they were not matched, and they can make this decision unilaterally as in the first condition.

Second, the no-blocking-contract condition is a standard one to define stability in a two-sided matching model with contracts (see, e.g., HM). It requires that there exist no merger contracts to which firms from both sides would be willing to deviate.

---

\(^{16}\)We slightly abuse notation when the chosen set \( \mathcal{C}_j(\mathcal{K}, \mathcal{N}_j) \) is not a singleton. In such cases, the payoff to firm \( j \) is exactly the same regardless of the choices in \( \mathcal{C}_j(\mathcal{K}, \mathcal{N}_j) \).
Lastly, our stability definition does not require conditions similar to Sasaki and Toda (1996)’s ϕ-admissibility, a condition that requires some sort of “consistency” between estimation and realized assignment. This is because we focus on myopic estimation function to guarantee existence of stable outcomes under which players treat other players’ choices as fixed in their estimation.\footnote{Note that externalities exist though other players’ choices are fixed in the estimation. A firm’s choice changes the number of operating firms in the market, and affects the payoff of all other players.}

The following (Ε-proposing) deferred acceptance algorithm by HM finds a stable outcome given $\mathcal{N}^*$ as we consider a myopic estimation.

1. Initialize $K_\mathcal{E} = \mathcal{K}$, $K_\mathcal{I} = \varnothing$.
2. All $e \in \mathcal{E}$ choose $\{e\}$, or make the offer that is most favorable to $e$ from $K_\mathcal{E}$ to members of $\mathcal{I}$.
3. All $i \in \mathcal{I}$ consider $\{i\}$, and all available offers, then hold the best, and reject the others.
4. Update $K_\mathcal{E}$ by removing offers that have been rejected. Update $K_\mathcal{I}$ by including newly made offers.
5. If there is no change to $K_\mathcal{E}$ and $K_\mathcal{I}$, terminate. Otherwise, return to Step 2.

We can also consider $\mathcal{I}$-proposing algorithm, which would entail making the following changes above: substituting $K_\mathcal{I} = \mathcal{K}$, $K_\mathcal{E} = \varnothing$ with $K_\mathcal{E} = \mathcal{K}$, $K_\mathcal{I} = \varnothing$ in (1); $e$ with $i$ in (2); $i$ with $e$ in (3); and $K_\mathcal{E}$ with $K_\mathcal{I}$ and $K_\mathcal{I}$ with $K_\mathcal{E}$ in (4). Note that this algorithm finds a stable outcome for any given myopic estimation, $\mathcal{N}^*$. If we consider a rational (non-myopic) estimation such as Sasaki and Toda (1996)’s ϕ-admissibility and Hafalir (2007)’s rational expectation, guaranteeing existence of a stable outcome becomes extremely difficult as Sasaki and Toda (1996) and Hafalir (2007) showed.

In each round each potential entrant offers a merger contract to an incumbent or chooses either of the outside options in step (b), and each incumbent holds the best contract offered or either of the outside options in step (c). The set of available contracts for $\mathcal{I}$, $K_\mathcal{I}$, starts with an empty set and expands \textit{monotonically} as more offers are (cumulatively) made each round. The set of available contracts for $\mathcal{E}$, $K_\mathcal{E}$, starts with the entire set of contracts in step (a), and it \textit{monotonically} shrinks as offers are rejected each round. HM show the existence of stable allocation and the characterization using this algorithm as follows.

\textbf{Theorem 1 (Hatfield and Milgrom (2005))} \textit{Given $\mathcal{N}^*$,}
(i) The set of stable contracts $\mathbf{K}^{*\mathcal{E}}$ is unanimously the most preferred set of contracts among all of stable contracts for $\mathcal{E}$ and unanimously the least preferred for $\mathcal{I}$, and vice versa for $\mathbf{K}^{*\mathcal{I}}$, i.e.,

\[
U_e(\mathbf{K}^{*\mathcal{E}}_e, N^*) \geq U_e(\mathbf{K}^{*\mathcal{I}}_e, N^*) \geq U_e(\mathbf{K}^{*\mathcal{I}}_e, N^*) \quad \forall \mathbf{K}^*_e, \forall e \in \mathcal{E},
\]

\[
U_i(\mathbf{K}^{*\mathcal{E}}_i, N^*) \geq U_i(\mathbf{K}^{*\mathcal{I}}_i, N^*) \geq U_i(\mathbf{K}^{*\mathcal{I}}_i, N^*) \quad \forall \mathbf{K}^*_i, \forall i \in \mathcal{I}.
\]

(ii) The $\mathcal{E}$-proposing algorithm converges to the $\mathcal{E}$-optimal stable outcome, $\mathbf{K}^{*\mathcal{E}}$, and the $\mathcal{I}$-proposing algorithm converges to the $\mathcal{I}$-optimal stable allocation, $\mathbf{K}^{*\mathcal{I}}$;

(iii) An unmatched firm in a stable outcome is also unmatched in any stable outcome.

We exploit this result in our estimation. First, part (i) of the theorem shows that there exists upper and lower bounds for the equilibrium payoffs of all firms. Though we do not know the equilibrium selection mechanism, equilibrium payoffs are always bounded above and below by these bounds. We use this result to construct moment inequalities in our estimation.

Second, to compute these bounds, we used part (ii) of the theorem in our estimation. Given parameter values and simulated draws of the shocks, we can run both the $\mathcal{E}$- and $\mathcal{I}$-proposing deferred acceptance algorithm with contracts to obtain these bounds.

Finally, part (iii) of the theorem implies that the set of firms that are unmatched is the same for all stable outcomes.\(^\text{18}\) This is the so-called “rural hospitals theorem” (Roth, 1986). Moreover, this implies that the payoffs of the unmatched players are the same because their outcome is unique in any equilibrium, i.e., $\forall i$ s.t. $C_i(\mathbf{K}^*_i, N^*) = i$ and $\forall e$ s.t. $C_e(\mathbf{K}^*_e, N^*) = e$

\[
U_e(\mathbf{K}^{*\mathcal{E}}_e, N^*) = U_e(\mathbf{K}^{*\mathcal{I}}_e, N^*) = U_e(\mathbf{K}^{*\mathcal{I}}_e, N^*) \quad \forall \mathbf{K}^*_e,
\]

\[
U_i(\mathbf{K}^{*\mathcal{E}}_i, N^*) = U_i(\mathbf{K}^{*\mathcal{I}}_i, N^*) = U_i(\mathbf{K}^{*\mathcal{I}}_i, N^*) \quad \forall \mathbf{K}^*_i.
\]

Thus, we can construct moment equalities in terms of the payoffs using the above equation for the firms that are unmatched.

\(^\text{18}\)Hatfield and Milgrom (2005) show a variation of the rural-hospitals theorem in the case of many-to-one matching with contract. They show that every hospital signs exactly the same number of contracts at every point in the set of stable allocations if the hospitals’ preferences satisfy what they call the law of aggregate demand and substitutability. This result implies that the set of hospitals that cannot fill the capacity in a stable allocation cannot fill it in any stable allocation. It does not necessarily imply the same set of doctors is hired in all stable allocations, though the number of unmatched doctors remains the same.

However, in our case of one-to-one matching with contract, preferences of both sides satisfy these two conditions. Therefore, we can show that the set of unmatched firms is identical in any stable outcome given $N$. 

15
3 Data

Before presenting the estimation and identification, let us discuss the data we use in the estimation. The banking industry in the U.S. provides us with an interesting and important change in entry regulation. At the beginning of 1995, intrastate de novo branching was not permitted in 12 states, and branching by merger was the only way to enter new markets in these states.\(^{19}\) The other 38 states fully permitted intrastate branching at that time. Then, in the following five years by the end of 2000, 8 of those 12 states have deregulated intrastate de novo branching. Focusing on these eight states allows us to study the effect of the intrastate branching regulation on the market structure.

We use the data on commercial banks in the U.S. from the local markets of the seven states in which intrastate branching was fully deregulated between 1995 and 2000.\(^{20}\) We use the data of three year periods right after the deregulation in each state. We obtain our main data on the branching of commercial banks from the Institutional Directory of the Federal Deposit Insurance Cooperation (FDIC). We augment the financial data of the banks with data from the Central Data Repository of the Federal Financial Institutions Examination Council. The data we construct contains information on the location of all branches and the financial statistics of every FDIC insured bank that had at least one branch in one of the seven states during the data period. The data also keeps track of the banks’ mergers and acquisitions. Data on merger contracts are obtained from the data set of SNL Financial, which reports deal values for each merger.\(^{21}\)

Markets in the banking industry are known to be local in nature.\(^{22}\) Existing works as well as antitrust analysis use geographic area as the definition of a market for the banking industry. Following Cohen and Mazzeo (2007) we focus our attention on rural markets, and we use a county as a market. This is because the typical market definition for urban areas (such as the Metropolitan Statistical Area) is likely to include submarkets within it. For this reason we exclude counties with a population greater than 50,000 from our data.\(^{23}\) In such markets, consumers are also very less likely to use banks in other markets.

As discussed in the model section, we classify banks into incumbents and potential

\(^{19}\) The only exception was Iowa, which deregulated entry by merger in 1997.

\(^{20}\) The 7 states are Arkansas, Colorado, Georgia, Montana, North Dakota, Oklahoma, and Wyoming. Our data do not include New Jersey because there was no county with population less than 50,000 in the state.

\(^{21}\) Merger data of SNL Financial do not necessarily have the same bank names as in FDIC data for the buyer and target banks. About a third of the mergers are matched by the FDIC certification number for both buyer and target banks. Another one third of the mergers are matched by the FDIC certification number of one side, and the holding company name and the FDIC holding company number. For the rest of the mergers, we matched manually using bank and holding company information from both data sets, and other sources such as regulatory filings. If a merger was still unmatched, we interpolated the transfer using buyer and target characteristics.

\(^{22}\) See, e.g., Ruffer and Holcomb (2001), Ishii (2005), and Cohen and Mazzeo (2007).

\(^{23}\) The number of markets does not change much if we use the criteria with a population less than 100,000.
Market (# of obs = 507) Mean Std. Dev. Min Max

<table>
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<th>Population (thousand)</th>
<th>15.5</th>
<th>11.0</th>
<th>0.6</th>
<th>49.0</th>
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<tr>
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<td>3,872.4</td>
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<td>93</td>
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<tr>
<td>Potential entrants per market</td>
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<td>12.5</td>
<td>5</td>
<td>90</td>
</tr>
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<td>Incumbents per market</td>
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<td>2.3</td>
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<td>24</td>
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<td>12</td>
</tr>
<tr>
<td>Number of mergers per market</td>
<td>0.7</td>
<td>0.9</td>
<td>0</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 1: Descriptive Statistics — Market Level

entrants in each market. We define banks that have operated in the market at the time of the deregulation as incumbents. Regarding potential entrants, banks that have operated in a contiguous market during the data period are defined as potential entrants. There is a small number of banks that have entered though they are not identified as potential entrants according to this definition. Hence, we added these banks to the set of potential entrants as well, which also includes a small number of newly established banks that account for 0.1% of the potential entrants. We define a firm entry if the firm exists at the end of our sample period.

Table 1 reports the summary statistics of the market-level information. On average, there are 3.9 incumbent banks and 25.6 potential entrants in a market. There is substantial variation across markets for the number of incumbents and potential entrants. Among those firms, the number of operating banks is 3.8 on average. The average number of mergers per market is 0.7.24

One of the assumptions of our empirical analysis is that the entry and merger decisions are independent across markets. Regarding this point, about 80% of the incumbents were present only in one market, and about 95% of the incumbents were present in less than three markets. Conditioning on entry, both the incumbents and potential entrants enter only one market in more than 75% of the cases and less than three markets in 95% of the cases for incumbents and 92% for potential entrants. Conditioning on entry with merger, both types of banks enter less than three markets in 87% of the cases. Thus, in the vast majority of our data, banks do not overlap across markets, and we treat markets independently. The fact that our data is mostly from small regional banks in small regional markets helps us on the independence assumption.

Table 2 reports the summary statistics of the bank-level information. The incumbents’

24During our sample period in our sample markets, there were no bank failure cases with open bank assistance by FDIC, while there were five bank failures where purchase and assumption (P&A) transactions were made. Since we observe such a small number of P&A transactions and cannot identify parameters specific to P&A, we treated these cases in the same way as other regular mergers.
<table>
<thead>
<tr>
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<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
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<tr>
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</table>

Table 2: Descriptive Statistics – Bank Characteristics by Incumbent and Potential Entrant, and by Mode of Entry: We report summary statistics of bank characteristics conditional on modes of entry, for amount of asset, amount of deposit, and equity ratio.
mean size of assets is much smaller than that of potential entrants at $6.45 billion. This may reflect the fact that we define potential entrants as banks in contiguous markets, which tend to be larger than the market we consider. Descriptive statistics on the equity ratio are roughly the same for incumbents and potential entrants with a mean of 10%.

Looking at the breakdown by the modes of entry, the incumbents that enter without merger are on average smaller than incumbents that enter with merger or do not enter. Potential entrants that enter by merger have the largest mean asset and deposit amount, while banks that do not enter have the smallest mean asset and deposit amount. Potential entrants that enter without merger is in-between them for both asset and deposit at $32.8 billion and $21.7 billion, respectively. Table 2 also reports the merger payment from buyer to target banks, which includes not only cash payment but also payment by share.

4 Identification and Estimation

In this section, we propose an estimation strategy for two-sided matching models based on moment inequalities and equalities. One of the major issues of estimating two-sided matching models is addressing the multiplicity of stable matchings. Our estimation strategy uses moment inequalities to deal with the issue of multiple equilibria similar to recent studies estimating noncooperative games by a set estimator (Ciliberto and Tamer, 2009, Ho, 2009, Kawai and Watanabe, 2013). We do so by exploiting the lattice structure of the set of equilibria (or stable outcomes, to be more precise).

4.1 Identification

4.1.1 Identified Set

Our identification is based on the restrictions provided by the inequalities (1) and (2) in Theorem 1 and the equalities (3) and (4). Theorem 1 shows that the payoffs in the two extremal equilibria (or stable outcomes to be more precise), $K^E$ and $K^I$, provide the upper and lower bounds of any equilibrium payoff. Hence they constitute the bounds of the payoffs corresponding to the observed matching and merger contract. Furthermore, equations (3) and (4) shows that, in any stable outcome, the payoffs of firms that do not merge are the same. This result leads us to construct moment equalities regarding the payoffs of non-merging firms. Hence the payoffs of the firms that are not merging should be equated to the payoffs of non-merging firms in $K^E$ and $K^I$.

Let us first revisit the result of Theorem 1 (more specifically, equations (1) and (2)): the two extremal stable outcomes provide the highest payoff to one side of the banks and the lowest payoff to the other side, i.e., (suppressing the dependence on $\mathcal{N}$ for notational
convenience) for any stable outcome $K^*$,

$$
U_e(K_e^*; \theta) \geq U_e(K^*; \theta) \geq U_e(K_e^I; \theta), \forall e \in \mathcal{E},
$$

$$
U_i(K_i^*; \theta) \geq U_i(K^*; \theta) \geq U_i(K_i^E; \theta), \forall i \in \mathcal{I}.
$$

In other words, given $\theta$ and $\mathcal{N}$, $e$’s payoff in any stable outcome is bounded above by the payoff in the $\mathcal{E}$-optimal stable outcome, $U_e(K_e^*; \theta)$, and bounded below by the payoff in the $\mathcal{I}$-optimal stable outcome, $U_i(K_i^*; \theta)$. Similarly the payoffs for all incumbents are bounded above and below by $U_i(K_i^E; \theta)$ and $U_i(K_i^*; \theta)$, respectively. Observe that we can compute these bounds given $\theta$ and $\mathcal{N}$ (and shocks) using the algorithm shown in Section 2.2 as shown in Theorem 1 (ii). We will come back to how we use the observed data pin down $\mathcal{N}$ in Section 5.

We also compute the payoffs for each firm $j$ corresponding to the data, $U_j(K_{DATA}^*; \theta)$, given $\theta$ (and shocks), where we denote the particular equilibrium selected in the observation as $K_{DATA}^*$. Though we cannot know which equilibrium the data-generating process corresponds to, the payoff corresponding to the equilibrium in the data must still be bounded by $U_j(K_i^E; \theta)$ and $U_j(K_i^*; \theta)$ for all $j$. Hence, we can consider the following types of inequalities:

$$
E \left[ U_e(K_e^*; \theta) - U_e(K_{DATA}^*; \theta) | X \right] \geq 0, \quad (5)
$$

$$
E \left[ U_i(K_i^I; \theta) - U_i(K_{DATA}^*; \theta) | X \right] \geq 0, \quad (6)
$$

$$
E \left[ U_e(K_e^*; \theta) - U_e(K_{DATA}^*; \theta) | X \right] \geq 0, \quad (7)
$$

$$
E \left[ U_i(K_i^*; \theta) - U_i(K_{DATA}^*; \theta) | X \right] \geq 0, \quad (8)
$$

where $X = \{(x_{i1}, ..., x_{in_e}), (x_{e1}, ..., x_{en_e}), z\}$ denotes firm characteristics of all firms in a market and market characteristics. Note that these inequalities are at the level of individual firms. However, our unit of observation is a market, and identity and number of incumbents and potential entrants differ across markets. Thus, we use moments based on these inequalities at market level in our estimation, which we describe in Appendix A (we construct 44 moment inequalities.).

Next, we discuss moment equalities resulting from equations (3) and (4), which state that unmatched (non-merging) firms earn exactly the same payoff in any stable outcome, i.e., for any $j$ choosing either $\{j\}$ or $\{o\}$, we have

$$
E \left[ U_j(K_{DATA}^*; \theta) | X \right] = E \left[ U_j(K^*; \theta) | X \right] = E \left[ U_j(K_e^*; \theta) | X \right]. \quad (9)
$$

Same as moment inequalities, these equalities are at the individual firm level, and we de-
scribe the moments we use in our estimation based on these equalities in Appendix A (we construct 14 moment equalities.). Note that we cannot construct the moments exactly as in 9 because different market contains different set of firms.

Finally, we define the identified set \( \Theta_{id} \) using both moment inequalities and equalities as \( \Theta_{id} = \{ \theta \in \Theta : \text{inequalities (5)-(8) and equalities (9) are satisfied at } \theta \} \). A few comments are in order. First, the identified set \( \Theta_{id} \) is not a singleton unless all inequalities bind. Because two-sided matching models do not have unique stable outcomes, these inequalities do not bind in general. Hence the model is only partially identified. Second, putting it informally, equality constraints provide restrictions that identify the parameters in payoffs for entry without merger, and inequality constraints provide restrictions that partially identify the synergy function. As several variables are included in payoffs for both entry with and without merger, we use both types of restrictions to construct our identified set.

### 4.1.2 Additional Restrictions that Help Identification

There are some additional restrictions that may help identification of the model. Though our estimation strategy is robust to lack of point-identification, we discuss how these other restrictions practically improve the identification of the model under certain conditions, i.e., the identified set \( \Theta_{id} \) becomes sharper to the extent that such conditions are satisfied in the data.

The basic idea of these additional restrictions is to consider two types of exclusion restrictions: the exclusion restriction employed in the regular entry model and the exclusion restriction for the synergy function. These two types of variables satisfying the exclusion restrictions help identification because \( x_i \) and \( x_e \) are included not only in the payoff of entering without merger but also in the payoff of entering with merger. Hence, those variables aid separating effects of \( x_i \) and \( x_e \) in payoffs of both cases.

The first type of exclusion restriction we consider is the same one as adopted in the literature on estimating entry models. As in Berry (1992) and Tamer (2003), we use a variable that affects a firm’s profit but does not enter the other firms’ profit functions. More precisely, a variable affecting fixed cost of entering a market but not affecting revenue and/or variable cost would satisfy such a requirement. In our setup, whether a firm is an incumbent or a potential entrant provides this variation. Though the discreteness of the incumbency dummy prevents us from making identification at infinity argument to achieve point-identification (see, e.g., Ciliberto and Tamer, 2009), variation of this incumbency dummy helps us make the identified set smaller.

The second type of exclusion restriction enhances identification of the (dis)synergy function, \( f \). Note that the first type of exclusion restriction is not useful for identification of \( f \) if all exogenous variables in \( f \) are also included in \( U_j(j, N) \) (payoff for entry without
merger). Thus, we consider a merger-specific variable that enters the synergy function of the particular merger, but affects neither the synergy of any other combination of firms nor the payoffs of the two firms entering without merger.

For this purpose, we use the distance between the headquarters of the incumbent and the potential entrant, which is the first element of $x_{ie}, x_{ie}^{(1)}$. This variable affects the post-merger synergy for various reasons, such as communication between the workers of the target and acquiring banks, while it is unlikely to affect the payoff of mergers of any other bank pairs and that of entry without merger.

We provide informal argument how these two excluded variables make the identified set smaller in two steps, where we use each type of restrictions in each step. First, we use the second type of exclusion restriction to improve identification of parameters that are not included in the synergy function. The assumption we use is that the dissynergy becomes larger as the distance increases.\footnote{To be more precise, the dis-synergy goes to infinity as the distance becomes infinity, i.e., $f(x_i, x_e, x_{ie}) \to -\infty$ as $x_{ie}^{(1)} \to \infty$.} This implies that the payoff with merger becomes strictly less than that of entering without merger with such large distance.\footnote{More precisely, the payoff for entry with merger goes to negative infinity as the distance goes to infinity, i.e., $\Pi_e(k_{ie}, N) \to -\infty$ and $\Pi_i(k_{ie}, N) \to -\infty$ without changing $\Pi_j(j, N)$ as $x_{ie}^{(1)} \to \infty$.} Although the distance cannot go to infinity in our data, this intuition carries over as long as the payoff with merger becomes low enough if the distance increases, and the firms have no incentive to choose mergers.

Now, given that the firms have no incentive to choose mergers, our model is equivalent to a regular entry model. This is because we can ignore the choice of entry with merger in such a case (it gives strictly lower payoff than not entering). Therefore, the first type of exclusion restriction helps to further identify the payoff of entry without merger, $U_j(j, N)$, as shown in Berry (1992) and Tamer (2003).

Second, we informally discuss how the synergy function can be better identified. Given the argument for $U_j(j, N)$ in the previous paragraph, we can use the variation of outcome $k_{ei}$ and that of characteristics $x_i, x_e, x_{ie}$ to improve identification of $U_i(k_{ie}, N)$ and $U_e(k_{ie}, N)$. Because the identified set on the effect of $x_i$ and $x_e$ on $U_j(j, N)$ becomes smaller by the first step, the effects of $x_i$ and $x_e$ on $U_i(k_{ie}, N)$ and $U_i(i, N)$ are isolated better. The same argument applies to $U_e(k_{ie}, N)$ and $U_e(e, N)$. Finally, as the effects of $x_i$ and $x_e$ on $U_i(k_{ie}, N)$ and $U_e(k_{ie}, N)$ are isolated better, the variation of $k_{ie}$ and that of $x_i, x_e, x_{ie}$ improves the identification about the synergy function $f$.

Note that the above discussion concerning these two types of exclusion restrictions helps the identified set to be smaller. We do not need the assumptions on the exclusion variables to be perfectly satisfied because our model are only partially identified and we estimate the model taking this fact into consideration. However, the degree to which these exclusion...
restrictions helps improve the identification of the model.

4.2 Estimation

Following the identification argument, we estimate the model using the moment inequality estimator developed by Andrews and Soares (2010). If an econometrician knew the equilibrium selection mechanism, a single outcome would correspond to one realization of the unobserved error terms \((\xi, \varepsilon)\). In such a case, we could employ estimation procedures such as GMM or MLE. However, as discussed in Section 4.2, the multiplicity of equilibria (stable outcomes in our case) implies that the model parameters are only partially identified: This makes the use of a set estimator more appropriate.

We denote all 44 moment inequalities and 14 equalities discussed in Section 4.2 (and described in Appendix A) by

\[
E[h_l(X; \theta)] \geq 0, \quad l = 1, \ldots, 44
\]

\[
E[h_l(X; \theta)] = 0, \quad l = 45, \ldots, 58
\]

Now we describe our estimation procedure using these moments. Our procedure solves the generalized Gale-Shapley algorithm with externalities for each simulation draw, and computes the sample analogue of moment inequalities and equalities in the following way.

1. Fix parameter \(\theta\). For each market \(m = 1, \ldots, M\), obtain \(S\) draws of \(\varepsilon_{ms} = \{\varepsilon_{ike}^{ms}\}_{i=1}^{N^m_{ms}}\), \(\varepsilon_{\xi}^{ms} = \{\varepsilon_{eim}\}_{e=1}^{N^m_{\xi}}\), and \(\xi_m^s\) from distributions \(g_{\varepsilon}, g_{\xi}, \text{ and } g_m\).

2. For each draw \(\eta^{ms} = (\varepsilon_{ms}^{\xi}, \varepsilon_{ms}^{\xi}, \xi_m^s)\) in each market \(m\), run an \(E\)-proposing generalized Gale-Shapley algorithm with externalities to obtain the \(E\)-optimal \(N\)-stable outcome. Run also an \(I\)-proposing generalized Gale-Shapley algorithm with externalities for the same draw \((\varepsilon_{Ims}^{\xi}, \varepsilon_{Ims}^{\xi}, \xi_{Ims})\) in the same market \(m\) to obtain the \(I\)-optimal stable outcomes.

3. Construct a sample analogue of the moment inequalities and equalities using the \(E\)-optimal and \(I\)-optimal stable outcomes as well as the observed match \(R^{**}\).

\[
\frac{1}{MS} \sum_{m=1}^{M} \sum_{s=1}^{S} h_l(X^m, \eta^{ms}; \theta) \geq 0, \quad l = 1, \ldots, 44
\]

\[
\frac{1}{MS} \sum_{m=1}^{M} \sum_{s=1}^{S} h_l(X^m, \eta^{ms}; \theta) = 0, \quad l = 45, \ldots, 58.
\]

The specific functions we use to construct test statistics and a critical value in Andrews and Soares (2010) are $S = S_1$ and $\nu_j = \nu_j^{(d)}$ with the number of bootstrapping $R = 1000$. Because we cannot report a 21-dimensional confidence set, we compute min and max of the confidence set projected on each dimension and report it in the next section (see Appendix B for details).

5 Results and Counterfactual Experiments

5.1 Parameter Estimates

The confidence intervals for the parameters are reported in Table 4. The exact specification of the payoff function for incumbent $i$ is

$$
\pi_i(i, N) = \alpha N + z_0 + x_i\beta_{11}^\text{size} + x_i^\text{eq}_1^\text{ratio} + \beta_{21}^i + \xi_m,
$$

$$
\pi_i(k_{ei}, N) = (1 - \tau_{ei})(\alpha N + z_0 + x_i\beta_{11}^\text{size} + \beta_{21}^i + \xi_m) + t_{ei},
$$

where $\xi_m \sim N(0, 1)$, and for potential entrant $e$ is

$$
\pi_e(e, N) = \alpha N + z_0 + x_e\beta_{11}^\text{size} + x_e^\text{eq}_1^\text{ratio} + \beta_{21}^e + \xi_m,
$$

$$
\pi_e(k_{ei}, N) = \tau_{ei}(\alpha N + z_0 + x_i\beta_{11}^\text{size} + x_i^\text{eq}_1^\text{ratio} + \xi_m) - t_{ei},
$$

where the synergy function in the payoff is specified as

$$
f(x_i, x_e, x_{ie}) = \beta_{2M} + x_i\beta_{31}^\text{size} + x_e\beta_{31}^\text{eq}_1^\text{ratio} + x_i^1 x_e^1\beta_{5}^\text{size} + x_i^2 x_e^2\beta_{5}^\text{eq}_1^\text{ratio} + d_{ie}\beta_{6,\text{dist}} + d_{ie}^2\beta_{5,\text{dist}2} + h_{ie}\beta_{6,\text{bhc}},
$$

where $x_{ie}$ consists of the distance between the headquarter of $i$ and $e$, $d_{ie}$, and the indicator variable for the same bank holding company, $h_{ie}$, i.e. $x_{ie} = [d_{ie}, h_{ie}]'$. $z$ is a vector of the market characteristics (log of population and log of per capita income), $x_i$ is incumbent $i$’s characteristics (log of total asset size and equity ratio), $x_e$ is potential entrant $e$’s characteristics (log of total asset size and equity ratio), $x_i^1 x_e^1$ is an interaction term of incumbent $i$ and potential entrant $j$’s asset size, $x_i^2 x_e^2$ is an interaction term of incumbent $i$ and potential entrant $j$’s equity ratio, and $\tau_{ei}$ and $t_{ei}$ are the terms of the merger contract $k_{ei}$ (payment by stock and cash). Note that $\beta_{21}^i$ and $\beta_{21}^e$ capture the size of entry barriers of incumbents and potential entrants for entry without merger, respectively, and $\beta_{2M}$ measures the cost of entry by merger. Finally, we consider $U_j(\pi) = \sqrt{\pi}$. 

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Table 3: Confidence Intervals. We report the 95% confidence intervals calculated following Andrews and Soares (2010).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Confidence Interval</th>
<th>Parameter</th>
<th>Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$</td>
<td>$[-1.763, -1.443]$</td>
<td>$\beta_3^{eq_ratio}$</td>
<td>$[-3.526, -1.085]$</td>
</tr>
<tr>
<td>$\beta_0^{pop}$</td>
<td>$[1.007, 1.231]$</td>
<td>$\beta_3^{size}$</td>
<td>$[-0.048, -0.018]$</td>
</tr>
<tr>
<td>$\beta_0^{income}$</td>
<td>$[0.227, 0.277]$</td>
<td>$\beta_4^{eq_ratio}$</td>
<td>$[2.326, 5.235]$</td>
</tr>
<tr>
<td>$\beta_1^{eq_ratio}$</td>
<td>$[0.115, 1.908]$</td>
<td>$\beta_4^{size}$</td>
<td>$[0.332, 0.406]$</td>
</tr>
<tr>
<td>$\beta_1^{size}$</td>
<td>$[-0.201, -0.109]$</td>
<td>$\beta_5^{eq_ratio}$</td>
<td>$[-22.598, -10.272]$</td>
</tr>
<tr>
<td>$\beta_1^{eq_ratio}$</td>
<td>$[0.367, 0.882]$</td>
<td>$\beta_5^{size}$</td>
<td>$[-0.028, -0.023]$</td>
</tr>
<tr>
<td>$\beta_2^{1E}$</td>
<td>$[-0.813, -0.665]$</td>
<td>$\beta_6^{dist2}$</td>
<td>$[-0.027, -0.006]$</td>
</tr>
<tr>
<td>$\beta_2^{IE}$</td>
<td>$[2.853, 5.705]$</td>
<td>$\beta_6^{dist}$</td>
<td>$[0.792, 3.187]$</td>
</tr>
<tr>
<td>$\beta_3^{eq_ratio}$</td>
<td>$[-8.651, -4.866]$</td>
<td>$\beta_{bhc}$</td>
<td>$[2.452, 7.765]$</td>
</tr>
<tr>
<td>$\beta_3^{eq_ratio}$</td>
<td>$[-1.912, -1.434]$</td>
<td>$\sigma_I$</td>
<td>$[0.632, 0.666]$</td>
</tr>
<tr>
<td>$\sigma_E$</td>
<td></td>
<td></td>
<td>$[0.747, 0.919]$</td>
</tr>
</tbody>
</table>

First, we discuss the estimates for the parameters in (dis-)synergy function $f$. The estimates for the effect of asset size for incumbents and potential entrants are $\beta_3^{size} = [-0.048, -0.018]$ and $\beta_4^{size} = [0.332, 0.406]$. That is, smaller incumbents and larger potential entrants have higher synergies. The interaction term for the incumbents’ and potential entrants’ asset size is $\beta_5^{size} = [-0.028, -0.023]$, which also implies that the smaller the incumbent and the larger the potential entrant, the higher is the synergy. The effects of the distance between two merging banks are $\beta_{6,\text{dist2}} = [-0.027, -0.006]$ and $\beta_{6,\text{dist}} = [0.792, 3.187]$ which indicates that the synergy becomes smaller as the distance between the merging firms becomes greater. The estimates confirm the pattern that small regional banks are acquired by relatively larger regional banks as our observation is focused on small regional markets.

The estimates for the synergy effect of the equity ratio exhibit a similar pattern. The results show that the equity ratio affects the synergy differently for incumbents and potential entrants based on the estimates of $\beta_3^{eq\_ratio} = [-3.526, -1.085]$ and $\beta_4^{eq\_ratio} = [2.326, 5.235]$. Incumbents with lower equity ratio have higher synergy, while a high equity ratio of a potential entrant impacts synergy positively. The estimate for the interaction term of equity ratio, $\beta_5^{eq\_ratio} = [-22.598, -10.272]$, implies that synergy is further strengthened if the equity ratio of the incumbent is low and that of the potential entrant is high. This result implies that less financially sound incumbents to are more likely to have higher synergies with healthy potential entrant banks.

Constant terms for incumbents and potential entrants are estimated as $\beta_{2E} = [-8.651, -4.866]$ and $\beta_{2I} = [2.853, 5.705]$, while that for the entry by merger is $\beta_{2M} = [-1.912, -1.434]$. 

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These constant terms are interpreted as sunk costs of entry for different forms of entry (entry with or without merger) for potential entrants and incumbents. Potential entrants have much higher entry costs if they enter de novo instead of entry by merger ($\beta_{2E} < \beta_{2M}$), which partly explains why potential entrants tend to enter by merger rather than de novo. Also, incumbents have much lower entry costs compared with potential entrants. These effects are significantly large, and are comparable to the competition effect that is estimated as $\alpha = [-1.763, -1.443]$.

Regarding bank characteristics, the estimates for the effect of equity ratio and asset size are $\beta_{eq_{ratio}}^{I} = [0.115, 1.908]$ and $\beta_{eq_{ratio}}^{E} = [0.367, 0.882]$, and $\beta_{size}^{I} = [-0.201, -0.109]$ and $\beta_{size}^{E} = [-0.813, -0.665]$, implying that a healthy balance sheet has strong effects on profitability and that a larger bank tend to be less profitable in small regional markets our data is from. Concerning market characteristics, the coefficients for both per capita income and population are positive. This implies that banks’ profits tend to be higher in markets with a larger population and higher income ceteris paribus.

Lastly, we discuss the estimates of the relative importance of idiosyncratic shocks on the payoffs. The estimates of the standard deviation are $\sigma_{I} = [0.632, 0.666]$ and $\sigma_{E} = [0.747, 0.919]$ compared to the market-level shock that is normalized to have standard deviation of one. This implies that idiosyncratic shocks are larger for potential entrants.

### 5.2 Counterfactual Experiment

We study the effects of the deregulation of entry restrictions by conducting a counterfactual experiment. The intrastate de novo entry had not been lifted in the 8 states by the end of 2000. Our data correspond to the period that is right after the deregulation of de novo entry. In our counterfactual, we simulate market structure by prohibiting de novo entry for potential entrants. The difference between the data and the predicted outcome of the counterfactual experiment presents the effect of the deregulation on the market structure.

Table 4 reports the results of the counterfactual experiment. We obtain our results by simulating the model without the choice of de novo entry for potential entrants (setting $\beta_{2E} = -\infty$) and letting the parameter values to move within the confidence set. Computational details are discussed in Appendix C. The results show that the number of operating banks would have been smaller if de novo entry was prohibited. As the last two rows of Table 4 show, the mean number of entry by merger is increased under the counterfactual. This is because prohibiting de novo entry by potential entrants increases the incentive for the potential entrants to enter by merger. However, the increase of entry by merger is not large enough to undo the decrease of de novo entry, resulting in smaller number of operating banks on average.
<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std Dev</th>
<th>10%-tile</th>
<th>Median</th>
<th>90%-tile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Operating Firms</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data</td>
<td>4.668</td>
<td>2.812</td>
<td>2</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td>Counterfactual</td>
<td>[4.039, 4.044]</td>
<td>[2.143, 2.144]</td>
<td>[1, 1]</td>
<td>[4, 4]</td>
<td>[7, 7]</td>
</tr>
<tr>
<td>Number of Entry by Merger</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data</td>
<td>0.598</td>
<td>0.815</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Counterfactual</td>
<td>[0.657, 0.757]</td>
<td>[0.965, 1.030]</td>
<td>[0, 0]</td>
<td>[0, 1]</td>
<td>[2, 2]</td>
</tr>
</tbody>
</table>

Table 4: Counterfactual Experiment: Effects of the deregulation. The counterfactual experiment prohibits entry without merger for potential entrants.

6 Conclusion

We study entry and merger decisions of banks jointly in this paper. We show the existence of the stable outcome in a two-sided matching model with externalities by proposing an algorithm. Using data on commercial banks in the U.S., we then estimate the model with a moment inequalities estimator based on the equilibrium characterization of the matching model without imposing an equilibrium selection mechanism. We find that entry barriers differ significantly across modes of entry and that synergy is larger when incumbent banks have a less healthy balance sheet and smaller size and potential entrants have larger asset size and healthier balance sheet.

There are many issues left for future research regarding firms’ merger and entry decisions. One issue we could not address was how entry by merger affects industry dynamics. A natural step would be to consider a merger as an additional investment tool in a dynamic industry competition model. Another issue concerns the way the externalities of post-entry competition affect firms. One can extend the model to consider the market with vertical or horizontal differentiations as in Mazzeo (2002) and Seim (2006).

References


7 Appendices

7.1 Appendix A: Moment Inequalities and Equalities

We describe the moment inequalities and equalities we use in our estimation. First, we have moment inequalities from mean of payoffs for potential entrants

\[
E \left[ \frac{1}{N_E} \sum_{e \in \mathcal{E}} \left[ U_e(K^*E; \theta) - U_e(K^{*DATA}; \theta) \right] \right] \geq 0,
\]

\[
E \left[ \frac{1}{N_E} \sum_{e \in \mathcal{E}} \left[ U_e(K^{DATA}; \theta) - U_e(K^{*I}; \theta) \right] \right] \geq 0,
\]

and the same for incumbents as well. Also, we consider the conditional moments for the mean payoffs of the potential entrants,

\[
E \left[ \frac{1}{N_E} \sum_{e \in \mathcal{E}} \left[ U_e(K^*E; \theta) - U_e(K^{*DATA}; \theta) | X \right] \right] \geq 0,
\]

\[
E \left[ \frac{1}{N_E} \sum_{e \in \mathcal{E}} \left[ U_e(K^{DATA}; \theta) - U_e(K^{*I}; \theta) | X \right] \right] \geq 0,
\]

as well as for the incumbents. In addition to the differences in mean payoff between the observed and upper (and lower) bounds, we consider quantiles as well. Denoting \( \alpha \)-quantile among the player \( \mathcal{E} \) by \( Q_{\alpha, \mathcal{E}}(\cdot) \), we use

\[
E \left[ Q_{\alpha} \left( U_e(K^*E; \theta) - U_e(K^{*DATA}; \theta) \right) \right] \geq 0,
\]

\[
E \left[ Q_{\alpha} \left( U_e(K^{DATA}; \theta) - U_e(K^{*I}; \theta) \right) \right] \geq 0,
\]
as well as for the incumbents. The quantiles we use for incumbents are 25%, 50%, and 75%. For potential entrants, we use 95%, and 99% because there is not much information for lower quantiles for potential entrants.

Regarding moment equalities, we have two types of equalities. The first type of equalities are regarding the number of operating firms, i.e.,

\[
E[N_{\text{merge}}^{\text{DATA}}|X] = E[\gamma(K^{*E}, N^{\text{DATA}}; \theta)|X] = E[\gamma(K^{*I}, N^{\text{DATA}}; \theta)|X],
\]

\[
E[N^{\text{DATA}}|X] = E[\lambda(K^{*E}, N^{\text{DATA}}; \theta)|X] = E[\lambda(K^{*I}, N^{\text{DATA}}; \theta)|X].
\]

The second type of equalities are about the payoffs of unmatched firms (from Part (ii) of Corollary 1). We take mean of the payoff of unmatched firms to construct moment equalities. Denoting the set of unmatched firms in each market by \(UM\) and the number of the unmatched firms by \(N_{UM}\), we have the following moment equalities;

\[
E\left[\frac{1}{N_{UM}} \sum_{j \in UM} U_j(K^{*E^{DATA}}; \theta)\right] = E\left[\frac{1}{N_{UM}} \sum_{j \in UM} U_j(K^{*E}; \theta)\right],
\]

\[
E\left[\frac{1}{N_{UM}} \sum_{j \in UM} U_j(K^{*I^{DATA}}; \theta)\right] = E\left[\frac{1}{N_{UM}} \sum_{j \in UM} U_j(K^{*I}; \theta)\right],
\]

\[
E\left[\frac{1}{N_{UM}} \sum_{j \in UM} U_j(K^{*E^{DATA}}; \theta)|X\right] = E\left[\frac{1}{N_{UM}} \sum_{j \in UM} U_j(K^{*E}; \theta)|X\right],
\]

\[
E\left[\frac{1}{N_{UM}} \sum_{j \in UM} U_j(K^{*I^{DATA}}; \theta)|X\right] = E\left[\frac{1}{N_{UM}} \sum_{j \in UM} U_j(K^{*I}; \theta)|X\right].
\]

In total, there are 44 moment inequalities and 14 moment equalities.

### 7.2 Appendix B: Computation of Table 3

The model has 21 parameters, and the confidence set, which we denote as \(CS\), is a 21-dimensional object. As we cannot present a 21-dimensional object in a convenient way, we present the min and max of the \(CS\) along each dimension in Table 3. In the following, we explain how we obtained the min and the max of the \(CS\) along each dimension.

Following the notation of Andrews and Soares (2010), a parameter value \(\theta\) is included in \(CS\) if \(T_n(\theta) \leq \hat{c}_n(\theta, 1 - \alpha)\) where \(T_n(\theta)\) is the test statistic and \(\hat{c}_n(\theta, 1 - \alpha)\) is the critical value. Denoting the \(j\)-th element of \(\theta\) by \(\theta^j\), we report \(\underline{\theta}^j = \min\{\theta^j | \theta \in CS\}\) and \(\overline{\theta}^j = \max\{\theta^j | \theta \in CS\}\). Though computing \(CS\) directly is extremely costly given that the \(CS\) has 21 dimensions, we can compute \(\underline{\theta}^j\) within manageable time by solving the following
constrained optimization problem for each of $j$-th dimension;

$$\min_{\theta^j} \quad s.t. \ T_n(\theta) \leq \widetilde{c}_n(\theta, 1 - \alpha),$$

where $\theta^j$ is the $j$-th element of $\theta$. By maximizing instead of minimizing $\theta^j$, we can obtain $\overline{\theta^j}$. We repeat this for $j = 1, \ldots, 21$ and report the solutions in Table 3.

### 7.3 Appendix C: Computation of Counterfactual

Though we cannot directly compute the 21-dimensional confidence set, $CS$, we can still conduct counterfactual policy experiments by imposing a restriction that the parameter values must satisfy the requirement for being included in $CS$. In computing the upper and lower bounds for an outcome of interest $y$ (say, number of operating firms), we solve the following constrained optimization problem similar to the problem in Appendix C;

$$\min_{\theta} \ y(\theta) \quad s.t. \ T_n(\theta) \leq \widetilde{c}_n(\theta, 1 - \alpha),$$

where the notations are same as in Appendix C. We compute the solution to the problem to have the lower bound for the outcome of interest $y$, such as mean and median numbers of operating firms. We also solve the corresponding maximization problem to obtain the upper bound for the outcome of interest.