Exploring the Incremental Merger Value from Multimarket Channels

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Abstract

We address the question through which channels mergers among multimarket firms create incremental value. We establish a theoretical model where incremental merger values depend on pre-merger market shares. Based on the pairwise stable equilibrium concept, we estimate firms' pair-specific merger value functions. Our results show that multimarket power, multimarket efficiency and multimarket strategic effects contribute majority of the incremental merger value. Moreover, we find that efficiency gains across multiple markets dominate multimarket power and multimarket strategic effects and contribute most to explaining post-merger value. Our estimated match values are aligned with the merging firms' post-merger stock market performance.

JEL: L10, L13, L20

Keywords: Efficiency Gains, Market Power, Matching, Merger Formation, Merger Value, Multimarket Competition.

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1 Introduction

Mergers have long been a popular strategy among firms, and they have become increasingly important over time, involving trillions of dollars spent on merger transactions every year.[1] A well-established fact in the merger literature is that a consolidation between firms can create value (see, e.g., Stigler (1950), Williamson (1968), Perry and Porter (1985), and Farrell and Shapiro (1990), Hitt et al. (2001), and King et al. (2004) among many others). Most mergers are formed among firms operating in multiple markets and it appears natural for firms to sort themselves into mergers based on the merger value created across multiple markets. Until now, the multimarket firm aspect has received little attention in the merger literature. Little is known about through which channels multimarket firms can create incremental merger value, and more insight is desired on the relative importance of these multimarket channels impacting merger values, as well as the heterogeneity of merger values generated by multimarket firms. Our study contributes to the merger literature as it explores how firms' multimarket characteristics contribute toward the resulting incremental merger value, where incremental merger value is the added value that firms' receive from merging that is beyond their respective firm specific values.

Our study explicitly focuses on firms' matching and sorting patterns into mergers (i.e., who merges with whom) to determine the incremental merger value and the features that drive this additional merger value.[2] We derive a simple theoretical framework that provides us with three potential drivers of multimarket merger value creation – those are, multimarket efficiencies, multimarket power, and multimarket strategic effects. The theoretical model considers an infinitesimal effect of a merger on market shares. This concept enables us to overcome challenges related to solving for post-merger market shares in closed form and to endogenize post-merger market shares with regard to market power and efficiency arguments. Using this theoretical framework, we adopt an empirical matching model and estimate firms' structural value functions that represent the preferences of merging firms over the characteristics of potential merging partners. We estimate to what extent the incremental merger value is driven by the three identified features, i.e., multimarket efficiencies, multimarket power, and multimarket strategic effects. We utilize a

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comprehensive dataset on the semiconductor industry that comprises information on 115 mergers for the years 1991-2004, as well as detailed firm-level production and innovation information. The concentration on this industry and the dataset is particularly useful for our purposes since a large number of firms are present in multiple product markets (such as dynamic random access memories, static random access memories, flash memories, etc.) and multiple technology markets. Varying market activity levels across firms result in differential potential merger gains across merging firm-pairs stemming from multimarket efficiencies, multimarket power, and multimarket strategic effects.

Our main results show that multimarket effects contribute (on average) 60% to the total merger-specific value added. We also find that multimarket efficiency effects are the highest value contributors to the incremental merger values, followed by multimarket power effects. With regard to multimarket strategic effects, our results show that merger value gains are at best moderate. This results suggests that either merger incentives related to post-merger price coordinations appears to be negligible, or firms were able to benefit from coordination effects across markets prior to merging already. These findings highlight the importance of considering multimarket effects when evaluating merger values. We find particularly strong support for multimarket efficiency gains being a major driver for mergers among multimarket firms. As such, our findings showcase the importance of considering firms' multimarket character when looking at incremental merger values. We also find that our estimated pair-specific incremental merger values are positively correlated with the acquiring firm's post-merger stock market performance, which provides support for our estimation procedure and for mergers being motivated by merger value creation per se.

Our study relates to several strands of literature. The first strand of literature is the growing literature concerned with the empirical estimation of mergers using a matching framework. This body of work has drawn on the empirical work by Sorensen (2007) and Fox (2018) and applied it to the study of mergers between mutual fund management companies (Park (2013)) and banks (Akkus et al. (2016)).[3] In our work, we follow the approach by Fox (2018), as is also done by Fox and Bajari (2013) and Baccara et al. (2012), that does not require transfer data for the purpose of estimation. An important difference of our implementation from Fox (2018) is that we do not assume a two-sided setup where firms from one set are assumed to merge only with firms from

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[3]The idea of applying matching models for the purpose of studying mergers was first put forth by Hall (1988).

another set. Instead, we employ a one-sided matching setup where any set of firms can choose to merge with any other firm.

The second strand of literature can be broken into three subsections, each being relevant to the potential drivers of incremental merger value creation (i.e., *multimarket efficieny*, *multimarket power*, and *multimarket strategic effects*) that our study highlights. First, one well established argument in the merger literature is the market power effect. Merging firms can internalize the competitive externalities they imposed on each other in a market pre-merger. This allows them to raise prices above pre-merger equilibrium prices, which increases firm value (see Stigler (1950), Williamson (1968), Salant et al. (1983), Perry and Porter (1985), Farrell and Shapiro (1990), and McAfee and Williamson (1992)). The extent to which competitive externalities can be internalized and market power can be achieved through mergers will likely be augmented in the number of markets that merging firms operate in; this defines the *multimarket power argument*.

A second argument that relates to merger value is the creation of efficiency gains. Merger-specific cost efficiencies could be caused by production rationalization, economies of scale, the unification of knowledge, innovation, or other technological complementarities, see also Raven-scraft and Scherer (1987) and Farrell and Shapiro (1990).[4] The U.S. Merger Guidelines Amendments (Section 4) from 1997 and the European Merger Guidelines in 2004 (Article 77) explicitly recognize the beneficial efficiency gains of mergers on consumer welfare.[5] In the multimarket merger context, it is reasonable to expect that merger value is composed of the sum of efficiency gains across markets, which defines the *multimarket efficiency effects*.

Third, firms' multimarket presence in product markets can have several strategic implications on firms' behavior. First, firms competing against each other in multiple markets can refrain from engaging in aggressive pricing behavior in one market to avoid aggressive responses in other mutual markets, also referred to as coordinated effects, or mutual forbearance.[6] Kahn (1950) and Edwards (1955) proposed the idea of "mutual forbearance" that multimarket contact weakens competition since firms avoid retaliation actions across multiple markets. The idea of

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[4]See also Bena and Li (2014), Focarelli and Panetta (2003), Harrison et al. (1991), Hitt et al. (1998), Larsson and Finkelstein (1999), Datta et al. (1992), Ramaswamy (1997), Sheen (2014), Shelton (1988), and Singh and Montgomery (1987).

[5]For further information on efficiency gains in horizontal mergers and homogeneous product markets, see also Jovanovic and Wey (2012), Roeller (2011), Roeller, Stennek, and Verboven (2001), Motta (2004), and Whinston (2007).

[6]For more information on multimarket competition, see Karnani and Wernerfelt (1985, page 87).

coordinated effects has been further stressed by Friedman (1971) and Abreu (1988) and formally characterized by Bernheim and Whinston (1990).[7] In the context of multimarket mergers, Kim and Singal (1993) contend that increases in multimarket contact among merging firms can alter firms' behavior in markets, which can facilitate coordination effects and lead to higher prices, which in turn translates into higher merger value (see Hughes and Oughton (1993), and Evans and Kessides (1994)). In contrast, Ciliberto and Williams (2014) remark that multimarket mergers can result in lower prices (and lower merger value) if firms' coordinated behavior already existed premerger. Similarly, if a merger is formed among multimarket firms, these firms will forego the possibility to engage in tacit collusion or mutual forbearance practices with the merging partner, which might then reduce the value of the merger. These strategic interdependencies between firms depends on their degree of multimarket interactions; this defines the *multimarket strategic effects* that captures the overall effect of these potentially countervailing forces, and as such, it can reveal which of the forces that is the more dominant.

The remainder of this paper is organized as follows: Section 2 presents our basic theoretical model. Section 3 outlines the matching model and our main hypotheses. Section 4 describes the industry and data sources, outlines our variable definitions, and presents data descriptives. We report our results in Section 5 and conclude in Section 6.

2   Basic Model

In the following, we introduce our basic theoretical framework, which purpose is threefold: First, it introduces the arguments through which multimarket firms can add value to mergers. Second, the model allows us to evaluate firms' merger value based on pre-merger market shares only; it avoids using post-merger equilibrium market shares. Third, it serves as a basis for specifying our empirical framework.

Our model is related to the study by Farrell and Shapiro (1990) which uses infinitesimal changes in firms' pre-merger outputs for their merger analysis. We consider quantity-setting

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[7]The majority of empirical studies finds that multimarket contact weakens product market competition and enables firms to sustain higher levels of profits and prices (see, e.g., Busse (2000) and Parker and Roeller (1997) on the telecommunications industry, Evans and Kessides (1994), Singal (1993), Miller (2010), and Ciliberto and Williams (2014) on the airline industry, and Heggestad and Rhoades (1978) and Rhoades and Heggestad (1985) on the banking industry). Further empirical studies in this area are Azar et al. (2015), Schmitt (2015), Jans and Rosenbaum (1994), Hughes and Oughton (1993), and Scott (1991), among others.

firms that can compete across different product markets, which are characterized by specific demand and cost structures. More specifically, we consider a setting where firms operate in multiple oligopolistic markets $m \in M$. N_m is the set of firms that are active producers in market m, and we also define $M_i \subseteq M$ as the subset of markets that firm i operates in. Goods within each market are homogeneous. Let the inverse demand in each market be given by $P_m(Q_m)$, where P_m is price in market m, Q_m is total output in market m, and the inverse demand is downward sloping $P'_m(Q_m) < 0$. Let q_{im} denote firm $i's$ output in market m and Q_{-im} denote the output of all firms except firm i in the same market. Total cost, $TC_m(q_{im})$, of firm i, in market m, is an increasing function of firm $i's$ output q_{im} ($\frac{\partial TC_m}{\partial q_{im}} > 0$). Firms choose quantities in order to maximize profits. The multimarket profit of firm i that operates across M_i markets is given by the sum of its single market profits:

$$\sum_{m \in M_i} \pi_{im} = \sum_{m \in M_i} \left(P_m(q_{im} + Q_{-im})q_{im} - TC_m(q_{im}) \right).$$

Merger Value

Merger value is defined as the difference between post- and pre-merger profits. To be able to formally describe these profits, we first need to define a few relevant sets and terms. Let $K_{ij} = \{m \mid m \in M_i \land m \in M_j\}$ be the set of markets that firms i and j have in common and let $K_{i \neg j} = \{m \mid m \in M_i \land m \notin M_j\}$ be the set of markets that firm i is active in, but not firm j. Similarly, we define $K_{j \neg i} = \{m \mid m \notin M_i \land m \in M_j\}$ the set of markets that firm j operates in. Moreover, $|.|$ denotes the absolute value for scalars and the cardinality for the sets. For example, $|K_{ij}|$ denotes the number of common markets for firms i and j (i.e., the number of elements of K_{ij}). The pre-merger profit of firm i that operates in markets M_i is given by:

$$\Pi_i = \sum_{m \in M_i} \pi_{im}. \tag{1}$$

We model a merger as a complete combination of the merging firms' assets and of the control of the merging firms. Hence, the post-merger (PM) profit of firms i and j is:[8]

$$\Pi_{ij}^{PM} = \sum_{m \in K_{ij}} \pi_{ijm}^{PM} + \left(\sum_{m \in K_{i \neg j}} \pi_{im}^{PM} + \sum_{m \in K_{j \neg i}} \pi_{jm}^{PM} \right), \tag{2}$$

where post-merger profit is composed of the profits across both common markets (first summand) and non-common markets (summands in brackets).

A merger between firms i and j is profitable, if:

$$V(i,j) = \Pi_{ij}^{PM} - (\Pi_i + \Pi_j) > 0, \tag{3}$$

where $V(i,j)$ is the merger-specific value added. Substituting equations (1) and (2) into equation (3), we can write the additional value generated by a merger as:

$$V(i,j) = \sum_{m \in K_{ij}} \pi_{ijm}^{PM} + \left(\sum_{m \in K_{i \neg j}} \pi_{im}^{PM} + \sum_{m \in K_{j \neg i}} \pi_{jm}^{PM} \right)$$

$$- \left(\left(\sum_{m \in K_{ij}} \pi_{im} + \sum_{m \in K_{i \neg j}} \pi_{im} \right) + \left(\sum_{m \in K_{ij}} \pi_{jm} + \sum_{m \in K_{j \neg i}} \pi_{jm} \right) \right) > 0, \tag{4}$$

which can be rewritten as:

$$V(i,j) = \sum_{m \in K_{ij}} \left(\pi_{ijm}^{PM} - \pi_{im} - \pi_{jm} \right) + \sum_{m \in K_{i \neg j}} \left(\pi_{im}^{PM} - \pi_{im} \right) + \sum_{m \in K_{j \neg i}} \left(\pi_{jm}^{PM} - \pi_{jm} \right) > 0. \tag{5}$$

Equation (5) informs us that both, common and non-common markets, between firms i and j will affect the merger-specific value added.

For further developing equation (5), we illustrate the channels through which merging multimarket firms can add value. We consider an infinitesimal effect of a merger on market shares, which allows us to build the analysis on pre-merger market shares. Since pre-merger market shares can be smaller or larger than post-merger market shares, we will have to consider the two cases of output-reducing and output-increasing mergers. For each case, we explore the conditions that need to apply for equation (5) to hold. The first case, i.e., an output-reducing merger $(\sum_{m \in M_i \cup M_j} q_{ijm}^{PM} < \sum_{m \in M_i} q_{im} + \sum_{m \in M_j} q_{jm})$, is summarized by Proposition 1 as follows:

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[8]A superscript PM refers to post-merger variables, while no superscript refers to pre-merger variables.

Proposition 1:

Suppose that multimarket firms i and j are involved in an output-reducing merger. This merger will add value, if:

$$V(i,j) = \sum_{m \in K_{ij}} \left(\frac{s_{im} + s_{jm}}{|\eta_{Q_{pm}}|} \right) |1 + \lambda_{ijm}| - \sum_{m \in K_{ij}} \left(\frac{\Delta TC_{ijm} + mr_{ijm}}{mr_{ijm}} \right)$$

$$+ \sum_{m \in K_{i \neg j}} \left(\frac{s_{im}}{|\eta_{Q_{pm}}|} \right) |1 + \lambda_{im}| - \sum_{m \in K_{i \neg j}} \left(\frac{\Delta TC_{im} + mr_{im}}{mr_{im}} \right)$$

$$+ \sum_{m \in K_{j \neg i}} \left(\frac{s_{jm}}{|\eta_{Q_{pm}}|} \right) |1 + \lambda_{jm}| - \sum_{m \in K_{j \neg i}} \left(\frac{\Delta TC_{jm} + mr_{jm}}{mr_{jm}} \right) > 0. \qquad (6)$$

Equation (6) shows us the common market (first summand) and non-common market (second and third summands) effects that contribute toward the merger value. Here, λ_{xm}, for $x = i, j, ij$, is the conjectural variation ; s_{xm}, for $x = i, j$, denotes the pre-merger market shares; $|\eta_{Q_{pm}}|$ is the absolute price elasticity of demand; mr_{xm}, for $x = i, j, ij$, is the marginal revenues, and ΔTC_{xm}, for $x = i, j, ij$, is the cost savings from merging in market m. Here, $\Delta TC_{ijm} = TC_m(q_{ij}^{PM}) - (TC_m(q_i) + TC_m(q_j))$ and $\Delta TC_{im} = TC_m(q_i^{PM}) - TC_m(q_i)$, where ΔTC_{jm} is similarly define.

It should be noted that equation (6) expresses the merger value, as originated by the market power effect and the internalization of competitive externalities, using pre-merger market shares, price elasticities of demand and the set of common markets. No post-merger market shares enter the equation and no closed form solution of post-merger market shares or further information on how post-merger market shares were generated are needed.

It is important to recognize in equation (6), since we consider an output-reducing merger, $\sum_{m \in M_i \cup M_j} q_{ijm}^{PM} < \sum_{m \in M_i} q_{im} + \sum_{m \in M_j} q_{jm}$, and given that $\partial TC_{xm}/\partial q_{xm} > 0$, for $x = i, j, ij$, it follows that $\Delta TC_{xm} < 0$ must apply, even in the absence of any merger-specific efficiency gains. The consideration of merger-specific efficiencies would provide further support for equation (6) to be satisfied since it further reduces ΔTC_{xm} which increases π_{ijm}^{PM}.

Proof: See Appendix A1.

In the following, we focus on Proposition 1 and discuss three multimarket effects that affect merger value. All three are originated by merging firms' common market presence (K_{ij}) as

illustrated in equation (6), line 1. First, as shown in line 1 of equation (6), merging firms characterized by larger pre-merger market shares in their common markets m $(s_{im} + s_{jm})$ add more value to mergers. In economic terms, larger firms impose higher negative competitive externalities on each other which can be internalized through merging. It further reduces post-merger output and raises post-merger price and profits, also known as the market power effect. Moreover, larger merging firms leave smaller firms outside the merger, causing smaller post-merger output responses which are less harmful to the merging firms' profits.[9] The market power effect becomes more powerful and further increases merger value if firms merge in markets with less elastic demands (represented by $\left|\eta_{Q_{pm}}\right|$ in equation (6), line 1). With less elastic demands, markups are larger and more profits are to gain from internalizing the competitive externalities. The fraction of market shares weighed by the elasticity of demand is also commonly referred to as the Lerner index in the economics literature and used as a proxy for firms' market power. The market power incentive, as shown in line 1 of equation (6), scales in the number of markets that the merging firms have in common (K_{ij}). This is plausible since a merger between multimarket firms removes, by definition, a competitor from multiple markets, which increases market power across multiple markets and adds incremental value to a merger. Hence, the merger value increases in the market power argument interacted with the number of common markets, which we refer to as *multimarket power effects*.

Second, line 1 of equation (6) indicates that merger value is also determined by strategic aspects related to firms' degree of competitiveness in product markets. These effects are captured by both the multimarket summand (K_{ij}) and the strategic or conjectural variation term (λ_{ijm}), and we refer to this as *multimarket strategic effect*. As mentioned above, this effect relates to an argument stemming from the multimarket contact literature, i.e., multimarket contact can serve as a strategic device by firms to soften competition (also known as tacit collusion, coordinated effects, or mutual forbearance). That is, multimarket firms may be competing less in a given market due to fears of retaliation within other common markets. As such, merger value may be derived from the strengthening of such coordinated effects following a merger.

Third, line 1 of equation (6) shows that the incremental merger value is increasing in the potential merger-specific cost savings in a market (ΔTC_{ijm}) and these benefits scale with the

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[9]Salant et al. (1983) show that the output response of non-merging firms matters for the profitability of a merger, i.e., smaller output responses are more valuable to merging firms.

number of common product markets K_{ij}. The efficiency gains increase output and profits due to outward shifts of the merging firms' reaction functions. We refer to these effects as *multimarket efficiency effects*. As shown in equation (6), lines 2 and 3, merger value also stems from firm-specific gains within non-common markets ($K_{i\neg j}$ and $K_{j\neg i}$).

The second case concentrates on an output-increasing merger ($\sum_{m\in M_i\cup M_j} q_{ijm}^{PM} > \sum_{m\in M_i} q_{im} + \sum_{m\in M_j} q_{jm}$), which is summarized by Proposition 2.

Proposition 2:

Suppose that multimarket firms i and j are involved in an output-increasing merger. This merger will add value, if:

$$V(i,j) = \sum_{m\in K_{ij}} \left(\frac{s_{im} + s_{jm}}{|\eta_{Q_{pm}}|} \right) (1 + \lambda_{ijm}) - \sum_{m\in K_{ij}} \left(\frac{\Delta TC_{ijm} - mr_{ijm}}{mr_{ijm}} \right)$$

$$+ \sum_{m\in K_{i\neg j}} \left(\frac{s_{im}}{|\eta_{Q_{Pm}}|} \right) (1 + \lambda_{im}) - \sum_{m\in K_{i\neg j}} \left(\frac{\Delta TC_{im} - mr_{im}}{mr_{im}} \right)$$

$$+ \sum_{m\in K_{j\neg i}} \left(\frac{s_{jm}}{|\eta_{Q_{Pm}}|} \right) (1 + \lambda_{jm}) - \sum_{m\in K_{j\neg i}} \left(\frac{\Delta TC_{jm} - mr_{jm}}{mr_{jm}} \right) > 0, \qquad (7)$$

where all the terms are defined as in equation (6).

Proof: See Appendix A2.

Equation (7) is similar to equation (6), and confirms that merger value depends on multimarket power, multimarket strategic, and multimarket efficiency arguments. Moreover, the earlier argument is confirmed that market power and the internalization of competitive externalities impact merger value, which can be expressed by using pre-merger market shares and elasticities. Hence, equations (6) and (7) require no information on how post-merger market shares are realized, and the model provides guidance for our empirical specification.

3   Empirical Matching Model

This section presents the matching model, discusses existence of stable matchings, introduces the match value function, and outlines how we estimate the parameters using a maximum score

estimation method. We also discuss the consistency of the estimates and introduce the applied numerical optimization method.[10]

3.1 Matching Model

We consider a finite set of firms F and an observable merger assignment $\mu : F \mapsto F$ that assigns firms into merger-pairs. A merged pair (i, j) receives merger value of $V(i, j)$. If the observed matches are based on a pairwise stable equilibrium concept, then it must be the case that firm i seeks to maximize $V(i, j)$ across all potential partner firms $j \in F \backslash \{i\}$ and, likewise, that firm j seeks to maximize $V(i, j)$ across its possible partner firms $i \in F \backslash \{j\}$. We focus on the notion of a merger as a bilateral agreement between two firms, as such, $V(i, j) = V(j, i)$ applies. Building on this concept, it follows that for any two observed merger pairs $\mu_{ij} = (i, j)$ and $\mu_{kl} = (k, l)$, there cannot exist a transfer ρ from μ_{ij} to μ_{kl} such that the bilateral exchange of partners specified by μ improves the outcomes of the firm-pairs. Therefore, for any transfer ρ the following conditions apply:

$$V(i, j) \geq V(i, k) - \rho \quad \wedge \quad V(k, l) \geq V(j, l) + \rho, \tag{8}$$

and

$$V(i, j) \geq V(i, l) - \rho \quad \wedge \quad V(k, l) \geq V(k, j) + \rho. \tag{9}$$

Adding the inequalities in equation (8),

$$V(i, j) + V(k, l) \geq V(i, k) + V(j, l), \tag{10}$$

must hold. Adding the inequalities in equation (9),

$$V(i, j) + V(k, l) \geq V(i, l) + V(j, k), \tag{11}$$

must apply. An assignment that satisfies both inequalities as shown in equations (10) and (11) is pairwise stable.[11]

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[10]While the matching literature is broad, recent empirical work builds on seminal contributions by Gale and Shapley (1962), Shapley and Shubik (1972), Becker (1973), Hall (1988), and Roth and Sotomayor (1990 and 1992)).

[11]Pairwise stability was first used by Gale and Shapley (1962) as a stability notion within matching games.

3.2 Existence of Stable Matchings

The model just presented is an instance of the classic (one-sided) roommates problem. This problem was initially studied by Gale and Shaply (1962) who pointed out that the classic roommates problem does not guarantee existence of a pairwise stable equilibrium.[12] To ensure existence of a pairwise stable equilibrium within our roommates problem with transferrable utility, we draw on results from the strategic network formation literature. In particular, our realized matches can more generally be thought of as constituting a (sparse) network. As such, we draw on Jackson and Watts (2001 and 2002) and Kim (2018) for the existence of a pairwise stable matching within our setup. First, Jackson and Watts (2001) show that for a certain class of value functions there exists no cycles within the resulting matching (or network). Second, Jackson and Watts (2002) show that for these types of games there exists at least one pairwise stable network or a closed cycle of networks. Lastly, Kim (2018) shows that for value functions such as ours (that depends on attributes of both merging firms) the result of nonexisting cycles by Jackson and Watts (2002) holds, and therefore, there must exist at least one pairwise stable equilibrium in our setting.[13]

3.3 Match Value Function Specification and Hypotheses

In choosing a match value function specification we draw on our theory. From equation (6), recall that the merger value was given by:

$$V(i,j) = \underbrace{\sum_{m \in K_{ij}} \left(\frac{s_{im} + s_{jm}}{|\eta_{Q_{pm}}|} \right) \underbrace{|1 + \lambda_{ijm}|}_{MMS_{ij}}}_{MMP_{ij}} - \underbrace{\sum_{m \in K_{ij}} \left(\frac{\Delta TC_{ijm} + mr_{ijm}}{mr_{ijm}} \right)}_{MME_{ij}}$$

$$+ \underbrace{\sum_{m \in K_{i \neg j}} \left(\frac{s_{im}}{|\eta_{Q_{pm}}|} \right) |1 + \lambda_{im}|}_{FMP_i} - \underbrace{\sum_{m \in K_{i \neg j}} \left(\frac{\Delta TC_{im} + mr_{im}}{mr_{im}} \right)}_{FE_i}$$

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[12]For additional details on the classic roommates problem, see Roth and Sotomayor (1990 and 1992)).

[13]For similar results for the case of nontransferable utility, see Rodrigues-Neto (2007) and Gordon and Knight (2009) who build on results by Tan (1991) and Cheung (2000).

$$+ \underbrace{\sum_{m \in K_{j \neg i}} \left(\frac{s_{jm}}{|\eta_{Q_{pm}}|} \right) |1 + \lambda_{jm}|}_{FMP_j} - \underbrace{\sum_{m \in K_{j \neg i}} \left(\frac{\Delta TC_{jm} + mr_{jm}}{mr_{jm}} \right)}_{FE_j} > 0. \qquad (12)$$

Broadly speaking, we see two components in equation (12). First, we have a common-market component given by the multimarket power effect (MMP_{ij}), the multimarket strategic effect (MMS_{ij}), and the multimarket efficiency effect (MME_{ij}). Second, we have two sets of non-common-market components given by the firm-specific market power effects (FMP_i and FMP_j) and the firm-specific efficiency effects (FE_i and FE_j). Building on equation (12), we choose a functional form for our match value function $V(i, j)$. We draw on previous empirical matching work and specify a linear form for our match value function (see, for example, Baccara et al. (2012) and Akkus et al. (2016)), that is, our match value function is given by:

$$V(i, j) = \underbrace{(MMS_{ij} + MMP_{ij} + MME_{ij})}_{v_{ij}} + \underbrace{(FMP_i + FE_i)}_{v_i} + \underbrace{(FMP_j + FE_j)}_{v_j} + \tau_t + \epsilon_{ij}. \quad (13)$$

Here, v_{ij} denotes the merger value due to common market effects, v_i and v_j are the firm-specific merger value components due to non-common market fixed effects, τ_t is the time fixed effects, and ϵ_{ij} is the merger-specific residual. Next, we substitute equation (13) into equation (10), which yields:[14]

$$V(i, j) + V(k, l) \geq V(i, k) + V(j, l),$$

$$\iff (v_{ij} + v_i + v_j + \tau_t) + (v_{kl} + v_k + v_l + \tau_t) > (v_{ik} + v_i + v_k + \tau_t) + (v_{jl} + v_j + v_l + \tau_t),$$

$$\iff v_{ij} + v_{kl} > v_{ik} + v_{jl}. \qquad (14)$$

Similarly, adding equation (13) into equation (11), we get:

$$v_{ij} + v_{kl} > v_{il} + v_{jk}. \qquad (15)$$

As such, our parameter estimates are free from any bias that would normally stem from failing to control for any firm-specific unobservable heterogeneities. This is a great benefit of the matching approach and has previously been noted within the literature (see e.g., Fox and Bajari (2013), Levin (2009) or Akkus et al. (2016)). From this, it follows that we are able to identify the

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[14]To keep the notation simple, we omit the residual ϵ_{ij} from equation (13).

incremental merger value part, v_{ij}, of the overall pair specific merger value $V(i, j)$. That is, we can estimate incremental payoffs, which we denote by $W(i, j)$:

$$W(i, j) = \underbrace{(MMS_{ij} + MMP_{ij} + MME_{ij})}_{v_{ij}} + \epsilon_{ij}. \tag{16}$$

As such, our empirical specification of equation (16) is given by:

$$W(i, j) = \theta_1 MMS_{ij} + \theta_2 MMP_{ij} + \theta_3 MME_{ij} + \epsilon_{ij}. \tag{17}$$

Before discussing our estimation approach for recovering the parameters (θ) within equation (17), we want to summarize a set of three hypotheses implied by this empirical specification and our basic theoretical model.

Hypothesis 1: *(Multimarket Strategic Effect, MMS) The incremental merger value is determined by multimarket strategic effects between firms across markets.*

Hypothesis 1 reflects the fact that the value of mergers is determined via strategic aspects between multimarket firms. In particular, multimarket mergers may act to increase coordination effects between firms, translating into higher prices (and higher merger value). However, multimarket mergers can also diminish coordination effects that existed pre-merger. This may result in lower prices and a lower merger value. As such, the direction and magnitude of this effect will depend on the degree of price coordination across markets prior to the merger.

Hypothesis 2: *(Multimarket Power Effects, MMP) Merger value increases in the merging firms' market power which scales with the number of markets that the merging firms have in common.*

Hypothesis 2 is based on the fact that merging multimarket firms gain from internalizing their negative competitive externalities which scale with the number of markets that the merging firms are active in together.

Hypothesis 3: *(Multimarket Efficiency Effects, MME) The merger value increases in efficiency gains which scale with the number of markets that the merging firms have in common.*

Hypothesis 3 states that mergers generate value via merger-specific efficiency gains which scale with the number of jointly operated markets.

The goal of our empirical model is to test these hypotheses. We now discuss how we estimate the parameters of our empirical model.

3.4 Maximum Score Estimation

Given our equation (17) for $V(i, j)$ and the inequalities implied by equations (10) and (11), we estimate the parameters using a semiparametric maximum score estimation technique which was first introduced by Manski (1975, 1985).Our objective function is given by:

$$Q(\theta) = \sum_{t \in T} \left(\sum_{\mu_{ij} \in M_t} \sum_{\mu_{kl} \in M_t} \mathbb{1}\left[W(i,j) + W(k,l) > W(i,k) + W(j,l)\right] + \mathbb{1}\left[W(i,j) + W(k,l) > W(i,l) + W(j,k)\right] \right),$$
(18)

where θ denotes the parameter vector of interest, and the inner two sums are taken over all possible match-pair combinations within the match market (set) M_t.[15] The index t of M_t refers to the year $t \in T = \{1991, 1992, ..., 2004\}$. The outer sum is then taken over all these separate matching markets (or years). The estimates $\widehat{\theta}$ maximize the number of times that the inequalities in equation (18) apply; that is, we choose $\widehat{\theta}$ to maximize the score $Q(\widehat{\theta})$ in equation (18).

This methodology was proposed by Fox (2018 and 2010), who provides consistency results for two cases: (i) when the matching market is defined as one large market and (ii) when there are many individual markets. Within our setup, we choose to treat each year as a separate merger market because comparing possible merger swaps across years does not seem desirable within a market where technological progress is drastic, making comparisons across time problematic.[16]

In terms of identification, this estimation approach allows us to identify the relative impact of different covariates on the incremental merger value $W(i, j)$ and the relative scale of these values across different mergers. Another benefit of this approach, as previously mentioned, is that any omitted variable that affects firms' merger value from merging with a particular firm is differenced out of the previous inequalities in equations (10) and (11) and therefore does not bias the parameter estimates from equation (17).[17]

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[15]Within our application the match market set M_t includes all theoretically feasible inequalities due to pairwise swaps. However, since some years contain firms that are part of multiple mergers we do not include pairwise swaps across matches that contain a common firm since these are theoretically not feasible.

[16]A similar market definition is employed by Akkus et al. (2016).

[17]For more of a discussion on the identification and bias correction, see Levine (2009).

Lastly, it should be noted that our objective function in equation (17) is not smooth. Consequently, numerical techniques are required to find parameter values that maximize the objective function. We follow the recommendation by Fox (2018) and employ a method known as differential evolution to find our parameter estimates (this method is also used by Akkus et al. (2015), Fox and Bajari (2013) and Levine (2009)).[18]

Next, we present details on the industry, our data sources, variable definitions, and descriptive statistics.

4   Industry and Data Descriptives

The semiconductor industry presents an appropriate setting for empirically exploring the determinants of merger values for several reasons. First, it is an industry that has experienced a substantial number of mergers. For the period 1991-2004, we observe 115 mergers in our sample. Second, firms within the semiconductor industry commonly compete across multiple product and technology markets. Competition takes place in memory markets such as the static random access memory (SRAM) market, the dynamic random access memory (DRAM) market, flash memory (FLASH) market, and the market for other integrated circuits (SEMI). Finally, it is one of the most important high-tech industries, with \$33 billion spent on R&D in 2013 (the highest share of revenues of any industry).[19] Much in accordance with the predictions of Moore's law (1965), the number of transistors that can be fit onto a chip has been roughly doubling every two years.[20] This rapid pace of innovation has also put pressure on the accumulation of intellectual property rights, with semiconductor firms often requiring access to a large stock of patents in order to advance their technology or to legally produce and sell their products (see Hall and Ziedonis (2001)).

The merger data is taken from the Thomson Reuters SDC Platinum database for global mergers, which includes mergers with a deal value of at least \$1 million. We study 115 mergers

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[18]For details on the estimation procedure and implementation, see Fox and Santiago (2014).

[19]Source: http://www.semiconductors.org/.

[20]For additional industry details, see Jorgenson (2001), who presents a nice account of the important role that the semiconductor industry has played, and continues to play, within the modern world of information technology. Starting with the invention of the first transistor at Bell Labs in 1947 and the milestone coinvention of the integrated circuit by Jack Kilby (Texas instruments) in 1958 and Robert Noyce (Fairchild Semiconductor) in 1959, these technological advancements laid the foundation for the modern microprocessors with functions that can be programmed by software.

across the time period of 1991-2004. Figure 1 shows the number of mergers for each of these years. The majority of mergers in our sample occurred in the years 1995-2004. We focus on mergers between firms that were active in technology and product markets. The product market activity data is compiled by Gartner Inc. and includes yearly production data for all four markets, SRAM, DRAM, FLASH, and SEMI. In our sample, all 230 firms are active within the product market, with 78 of these being active across multiple product markets. Part 1 (of Table 1) provides further details on the product market presence of our sample, and shows that 24 of the multimarket firms are active within two markets, 44 are active within three markets and 10 are active within all four markets. Part 2 (of Table 1) provides additional details on the product market presence of firms. As shown, 60 firms are active in the SRAM market, 54 are active in the DRAM market, 30 are active in the FLASH market, and 228 are active in the SEMI market. Our patent data is retrieved from the United States Patent and Trademark Office and was obtained from the National Bureau of Economic Research (NBER) Patent Database (for details on this database, see Hall et al. (2001)).[21] All firms in our sample are active technology firms with positive patent stocks. Finally, our firm-level financial data is from Compustat at WRDS, DataStream, and Wolfram Research.

Using our data on intellectual property rights and product market activity, we define several merger-specific measures in order to empirically test the hypotheses presented in the previous section.

The first hypothesis states that the merger-specific value will be determined by the merging firms' multimarket strategic effect (MMS). To control for this effect we need a measure that will capture the degree of multimarket contact between the merging firms i and j. This variable is defined as the market overlap count (MOC):

$$MOC_{ij} = \sum_{m \in K_{ij}} \mathbb{1}[m \in K_{ij}],$$

where $\mathbb{1}[.]$ is an indicator function taking the value of 1 if the market m is common to both firms and 0 otherwise. Since there are 4 markets within our data, the MOC measure can take on values from 0 to 4. This is a commonly applied measure of multimarket contact (see Evans and

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[21] A crosswalk was devised to match firms in the production dataset to firms in the patent data. This matching was done using the firm names.

Kessides (1994) and Gimeno and Woo (1996)).

To test our second hypothesis, we control for multimarket power effects (MMP) as follows. First, let s_{im} denote firm $i's$ market share in product market $m \in \{SRAM, DRAM, FLASH, SEMI\}$. Given the market presence of firms i and j, we define our market share complementary adjusted by price elasticities measure (MSC) as:

$$MSC_{ij} = \sum_{m \in K_{ij}} \frac{s_{im} * s_{jm}}{|\eta_{Q_{pm}}|},$$

where the sum is taken over all the markets $m \in K_{ij}$ that firms i and j have in common, and $\eta_{Q_{pm}}$ refers to the price elasticity of demand within market m.[22,23]

The third hypothesis states that firms sort into merger pairs on the basis of efficiency gains. To empirically approximate this notion of efficiency, we draw upon Cohen and Levinthal's (1990) idea of absorptive capacity, which states that more similar firms are able to extract more value from one another's activities. As such, firms that are more "similar" in terms of their technologies (or knowledge) are able to benefit from higher synergy effects. We refer to this notion of knowledge relatedness as technological proximity (TP). To capture the technological proximity of firms, we use the uncentered correlation between firm $i's$ and firm $j's$ patent portfolios. We let $\Gamma_i = (\Gamma_{i1}, \Gamma_{i2}, ...)$ be firm $i's$ patent portfolio, where Γ_{ik} denotes the number of patents that firm i holds in patent class k.[24] Our technological proximity measure is:[25]

$$TP_{ij} = \frac{(\Gamma_i \Gamma_j')}{(\Gamma_i \Gamma_i')^{\frac{1}{2}} (\Gamma_j \Gamma_j')^{\frac{1}{2}}},$$

where $TP_{ij} \in [0, 1]$ is increasing in the degree of patent portfolio overlap of firms i and j.[26] In

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[22]In choosing our $\eta_{Q_{pm}}$ measures we draw upon previous studies and use the following values: -3.3 for SRAM, -2.4 for DRAM, -3.5 for FLASH and -2 for SEMI.

[23]It should be noted that the specification of our MSC variable uses the product between the market shares rather than the sum of these market shares (which was suggested by our theoretical model). This is explained by a limitation of the matching approach that we employ in our empirical analysis–in particular, these models are unable to identify a parameter on a firm characteristic that is not interacted with the characteristic of any other firm (see Fox (2018)).

[24]We used data on the following 10 patent classes: 257 (active solid state drives), 326 (electronic digital logit circuitry), 438 (semi-devices manufacturing process), 505 (super conductor technology apparatus, material, and processes), 360 (dynamic magnetic information storage and retrieval), 365 (SRAM), 369 (DRAM), 711 (FLASH), 712 (computer processors etc.), and 714 (error detection and correction).

[25]To ensure that TP_{ij} is defined for all possible firm-pairs within our dataset, we consider only firms with non-zero patent portfolios, i.e., we focus on technology firms. Also, to avoid endogeneity concerns related to our technology and market share measures, we use lagged values of these measures from period $(t-1)$.

[26]For applications of this proximity measure within the industrial organization literature, see, for example, the

addition to technological proximity, we also want to control for the possible interaction between firms' technological complementarity and their multimarket interaction. As such, we define our multimarket technology measure (MMT) as the interaction between the number of common markets and our technological proximity measure (TP):

$$MMT_{ij} = \sum_{m \in K_{ij}} \mathbb{1}[m \in K_{ij}] * TP_{ij},$$

where $\mathbb{1}[.]$ is an indicator function as previously defined. Both measures, TP and MMT, are used to control for the multimarket efficiency effect (MME) of a merger.

Lastly, we include firms' patent stocks as an additional control variable for the selection of a merger partner. The reason for this is that larger patent stocks may provide more opportunities for meaningfully recombining firms' patents in order to derive additional merger value. Our patent stock measure is defined as the product of the two firms' individual log patent stocks:

$$PS_{ij} = log\left(PatStocK_{i \neg j}\right) * log\left(PatStocK_{j \neg i}\right),$$

where $PatStocK_{i \neg j}$ denotes the discounted patent stock of firm i.[27]

Having delineated each of our measures, along with the incremental merger value incentives that each seeks to capture, we want to acknowledge that there may exist an overlap in terms of the effects that each of these measures capture. Given the present status quo of the empirical literature and the difficulty in disentangling these effects, we acknowledge the richness of our data and the variable definitions.

Table 2 provides summary statistics for our variables across two samples. The first sample consists of our 115 realized mergers. The second sample considers a placebo experiment of hypothetical mergers of randomly merged firms. Comparing Columns (1) and (2) in Table 2, we note that merged firms tend to match on multimarket strategic effects (means: $1.30 > 1.11$), multimarket power effects ($0.003 > 0.001$), multimarket efficiency arguments ($0.57 > 0.49$ for TP, and $0.81 > 0.57$ for MMT), and also on the size of the firms' (log) patent stocks ($24.50 > 23.42$).[28] These findings are well aligned with our hypotheses.[29]

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original application in Jaffe (1969), and, more recently, Bloom, Schankerman, and Van Reenen (2010).

[27]The patent stock measures have been discounted using a discount factor of 0.85 (see Hall et al. (2001)).

[28]Note that we reported the sample means from Table 2 here.

[29]Assortative matching of merging firms has been noted previously within the merger literature, see e.g. Rhodes-

5 Results

Table 3 presents our estimation results for two different specifications of the incremental merger value function. Adopting Fox's methodology, we fix one of the estimates to unity (± 1). This is done for the patent stock parameter, and it implies that the scale of all other point estimates are estimated relative to the patent stock.[30] We are able to get point estimates for our parameters because at least one of our variables have a continuous support. In the absence of such a support the estimator would have instead been set-identified (see Fox and Santiago (2014, p. 11) for additional details). We report the 90% confidence regions below each of the point estimates. The confidence regions are obtained by drawing 100 subsamples without replacement, where the subsample size consists of 12 (out of 14) merger markets (years).[31]

The first column of Table 3 controls for the variables MOC, TP, and PS. This specification predicts 64 percent of the 1,188 inequalities. It shows us that technological complementarities, knowledge relatedness, and the degree of multimarket overlap contribute positively and significantly toward the pair-specific incremental merger value creation. In the second column, we add the additional controls for market share complementarity adjusted for price elasticities (MSC) and multimarket technology (MMT). This is our main specification since it addresses all the hypotheses from Section 3 and it explains the largest share of inequalities (66 percent of the 1,188 inequalities).

In comparing columns (1) and (2), we note that the coefficient for TP is significant across both, and the coefficient estimate for MMT is also significant within our main specification. This suggests that efficiency arguments matter and their importance depends on the multimarket interdependence of the merging firms. We also note that the coefficient for our market overlap count (MOC) measure is positive and significant in the first specification, and while it remains positive within the main specification, it is no longer significant when we add the additional multimarket controls MSC and MMT. We now relate these results to our hypotheses of Section 3 to derive further economic content.

The first hypothesis implies that merger value depends on multimarket strategic effects. We

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Kropf and Robinson (2008).

[30]Note that for each specification in Table 3, we ran the estimation for $\theta_1 = +1$ and $\theta_1 = -1$. We report those results that returned the highest score (largest percentage of inequalities satisfied).

[31]For more details on the subsampling, see Fox and Santiago (2014).

also argued that the anticipated effect on the resulting merger value may be ambiguous since it depends on the level of collusion prior to the merger taking place–while a merger can help facilitate coordination effects that lead to higher prices (and higher merger value), it may also reduce prices (and overall merger value) if firms already engaged in price coordination prior to the merger and the merger diminishes coordination effects. Looking at our two specifications, we see that we obtain a positive point estimate for our coefficient on the MOC variable in column (1) and column (2) of Table 3. However, the effect is not statistically significant when we include our other multimarket controls (MSC and MMT) into the main specification of column (2). This finding suggests that merging firms appear to be engaging in moderate price coordination prior to their merger, and as such, the merger-specific gain from further price coordination appears to be at best moderate.

The second hypothesis is confirmed as firms seek to merge due to multimarket power effects, which we capture empirically using our market share complementarity (MSC) measure. Our main specification in column (2) shows that MSC is strongly and significantly correlated with merger value.

The third hypothesis states that merger value derives from multimarket efficiency arguments. Our main specification in column (2) of Table 3 provides support for this hypothesis by showing positive and statistically significant coefficient on the technological proximity (TP) and multi-market technological (MMT) effects. Thus, we find that both multimarket efficiency gains and multimarket power effects importantly contribute toward merger value.

The estimation results from Table 3 are further used to obtain estimates of the pair-specific component (v_{ij}) of the overall unobserved merger values.[32] These are showcased in Figure 2. Note that since only the relative difference of these values matters, we have scaled them by the median pair-specific merger value. As such, the median firm has a value of 1, while half of the merger values are located to the left (and right) of the median merger. Figure 2 shows that the values range from 0.03 to 3.0, which indicates a substantial amount of heterogeneity in merger values. The long right tail within this distribution further indicates that there are some mergers that result in exceptionally high merger values. This finding is interesting because it suggests that firms face scarcity in the number of good matches, something that may induce them to

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[32]Recall that $V(i,j) = v_i + v_j + v_{ij}$ and that we estimate the final v_{ij} component since v_i and v_j cancel out.

compete for attractive partner firms. As we have previously argued, these strategic interactions have implications on the resulting merger assignment and, therefore, need to be controlled for within the empirical approach–something we have done by virtue of using a matching model.

Lastly, we want to investigate the relative contribution of each of our controls with respect to the total additional merger-specific value added. This is established by dividing the mean contribution of each control by the mean pair-specific merger value, v_{ij}.[33] This analysis informs us that multimarket effects (measured by MOC, MSC, TP and MMT) contribute close to 60% of the total additional merger value, while the remaining value is contributed by merger-specific cost savings and efficiencies (captured by the PS variable). These findings suggest that within multimarket settings firms' merger decisions will be influenced by the firms' multimarket characteristics. Of particular interest is the finding that the multimarket efficiency effects (captured by MMT) dominate both multimarket power (captured by MSC) and multimarket strategic (captured by MOC) effects.

5.1 Pair-Specific Merger Value and Merger Performance

We explore whether our fitted pair-specific merger values predict realized post-merger performances. We view this as a specification test where a positive correlation between our estimated merger values and the post-merger performances provides support for our value function being appropriately specified.

To investigate this relationship, we take our fitted merger values and use them to predict merger performance. We define merger performance as the difference between the acquiring firm's stock market price relative to the performance of the general market, which we proxy using the performance of the S&P 500. In particular, we do this by comparing the cumulative fractional changes (CFC) of the firms in relation to that of the cumulative fractional change of the S&P 500 as a whole. We concentrate on two periods: (i) one week before the merger announcement until one day after the merger announcement date ($1wb1da$) and (ii) one month before the merger announcement until six months after the merger effective date ($1mb6ma$). The former of these measures aims to capture the markets anticipation of the merger value at the announcement of the merger, while the second measure seeks to capture longer term post-merger performance after the

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[33]For example, to assess the relative contribution of PS we compute $\left(\hat{\theta}_1 * \overline{PS}\right)/\overline{W(i,j)} = (1 * 24.5)/60.3 = 0.4$, where $\overline{PS}$ is the average PS across all realized mergers, and $\overline{W(i,j)}$ is similarly defined.

merger's effective date. As an example of the second measure, Figure 3 presents a visualization of the stock market performance of Fujitsu Ltd., who merged with Hitachi Ltd. in April of 1999. Fujitsu's stock market price is depicted by the blue (top) solid line, while the performance of the S&P 500 is illustrated by the orange (lower) solid line. These lines show each party's cumulative fractional change over this two-month period. The relative performance of Fujitsu to the S&P 500 index is given by the difference between these cumulative fractional changes at the end of the time period, i.e., the gap between the two lines at the far right of Figure 3.

These measures of acquirer performance are regressed on the fitted merger values that we obtained using specification (2) in Table 2 and on controls for the merging firm's market values.[34] The regression results are reported within Table 4. Across both the regressions using the $1wb6ma$ measure for the cumulative fractional change, we note that our pair-specific merger value measure (v_{ij}) appears to be significant at the 5% level (specifications 3 and 4). The positive sign of the measure implies that a higher merger value is positively correlated with our estimates of merger performance.

To summarize, we find a significant positive correlation between our estimated merger value measure and the post-merger performance of the acquiring firm's stock price relative to the performance of the S&P 500 for the same time period. This finding lends support to our model being appropriately specified, in that conditional upon merger, firms appear to be sorting into merger pairs so as to maximize post-merger pair-specific value.[35]

6   Conclusion

The multimarket firm aspect has received little attention in the merger value literature. Since the real merger value is frequently unobserved, quantifying or proxying the incremental merger value is a difficult task. The goal of this paper has been to identify and quantify through which multimarket channels mergers among firms operating in multiple common markets can create additional merger value. Our theoretical model provided us with several arguments on how mergers among multimarket firms can increase value, i.e., the *multimarket power*, *multimarket*

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[34]These regressions are performed using standard ordinary least squares (OLS) with robust standard errors. The fitted merger values used are those reported within Figure 2.

[35]It should be noted that this does not imply that mergers are, in general, value generating; rather, it means that conditional upon deciding to enter the merger market, firms will sort into merger pairs so to maximize their resulting pair-specific merger value.

efficiency, and *multimarket strategic effects.* We derived three hypotheses that we set out to test using an empirical structural framework. Our structural model provides estimates of the unobserved pair-specific merger value components. We use a matching model to characterize the merger market because it allows us to account for strategic interactions between firms and the notion that mergers, within our setting, are best thought of as being outcomes of mutual agreements.

The estimation results of firms' pair-specific merger value functions show that firms match into merger pairs based on several multimarket driven effects. In particular, we find that the multimarket effects (on average) contribute close to 60% toward the pair-specific merger value added—a considerable amount. Among the multimarket effects, we find that multimarket efficiency gains are the largest contributor to merger values; they dominate multimarket power and multimarket strategic arguments. The multimarket strategic effect (controlled for using our MOC measure) has a positive point estimate but is not significant in our main specification. As mentioned earlier, the multimarket strategic effect can go in opposite directions. On the one hand, a multimarket merger can reduce the number of firms competing across market and increase coordination effects which increases merger value. In contrast, the merging multimarket firms could have coordinated prices already prior to merging, such that multimarket strategic effects would not have manifested in additional merger value. Our results also show that firms' multimarket positioning across both technology and product markets affect the incremental merger value.

Our results show that our estimated pair-specific merger values are positively correlated with the acquiring firm's post-merger stock market performances. While this does not imply that mergers are in general value creating, it does suggest that firms within the merger market tend to sort into merger-pairs in order to maximize post-merger performance. This result supports the reliability of our merger value estimation which builds on revealed preferences within a matching framework.

Further work in this direction seems warranted as it may provide more insight into the determinants of merger value creation in other industries and settings. More work that concentrates on further untangling the possible multimarket strategic effects is desired. This paper has shown that drawing upon recent developments of matching models for structural empirical work may be well suited for merger valuations.

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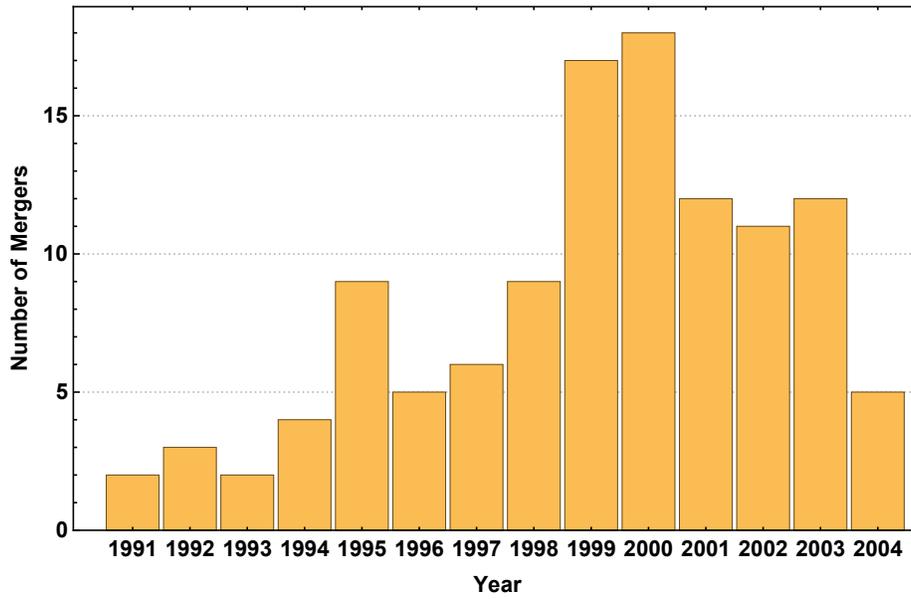
Figures

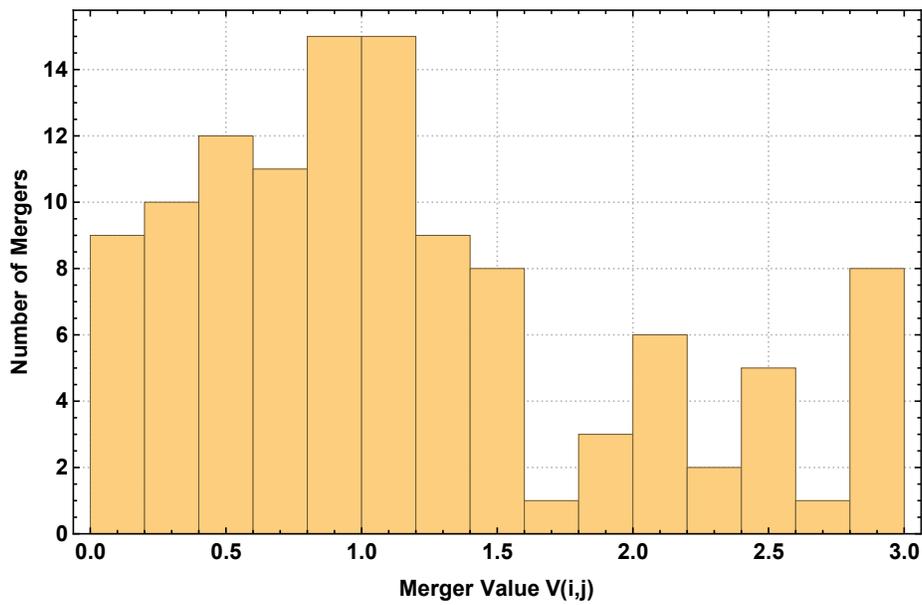Figure 1: Number of Mergers Over Time (1991-2004).

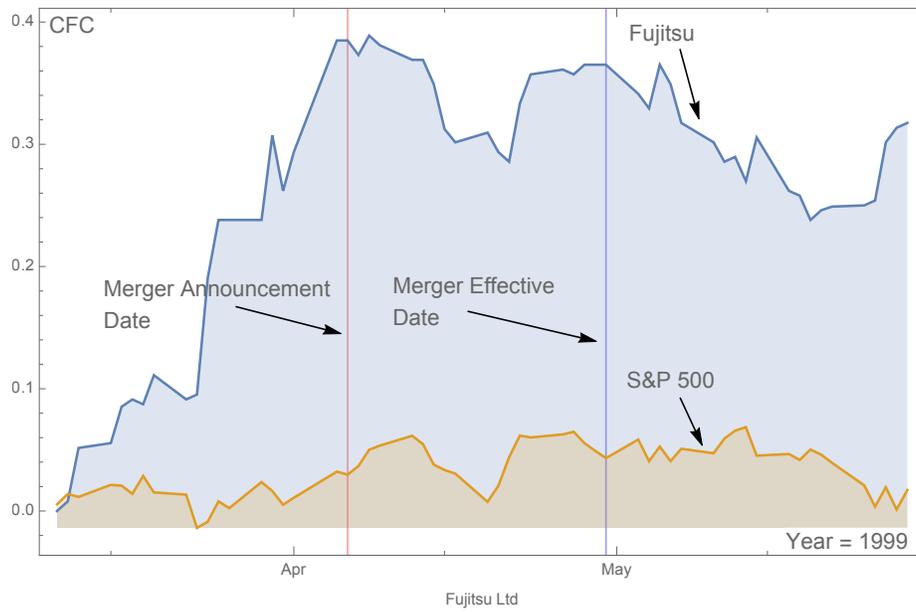Figure 2: Estimated Pair-Specific Merger Values.

Figure 3: Measure of Merger Performance. The figure shows the cumulative fractional change (CFC) of Fujitsu's stock market price (blue solid line) for the period of one month before the merger announcement and one month after the merger was confirmed (effective date). The merger announcement and confirmation date are the same here. They are visually represented by the vertical line that divides the figure into two parts. Merger success is taken to be the amount by which the firm outperforms the S&P 500 (orange solid line) for the full extent of this period of time.

Tables

Part 1: Product Market Presence				
Numb. of Markets:	1	2	3	4
Numb. of Firms:	152	24	44	10

Part 2: Product Market				
Market:	SRAM	DRAM	FLASH	SEMI
Numb. of Firms:	60	54	30	228

Table 1: Summary Statistics. Part 1 describes the product market presence of the 230 firm observations (115 mergers) in our sample. Part 2 describes the firms' market presence in each specific product market.

Variable	(1) Realized Mergers		(2) Random Mergers	
	Mean	Std. Dev.	Mean	Std. Dev.
MOC	1.300	0.713	1.114	0.468
MSC	0.003	0.011	0.001	0.004
TP	0.570	0.319	0.485	0.286
MMT	0.813	0.796	0.575	0.520
$PS^{\dagger}$	24.502	24.160	23.358	21.190
N	115		2,333	

$\dagger$ – denotes variables defined in logs.

Table 2: Summary Statistics of Variables. These are provided for two cases: (i) realized mergers and (ii) randomized mergers.

Variables	(1) V(i,j)	(2) V(i,j)
MOC	8.8***	0.7
	[8.0 , 14.4]	[-1.3 , 2.1]
MSC	-	88.3***
	[- , -]	[70.5 , 204.4]
TP	13.7*	42.8*
	[9.6 , 25.0]	[43.3 , 78.9]
MMT	-	12.6*
	[- , -]	[2.9 , 22.5]
PS	+1	+1
	[1 , 1]	[1 , 1]
Numb. Mergers:	115	115
Numb. Ineq.:	1,188	1,188
% Ineq. Satisfied:	64%	66%

Table 3: Maximum Score Estimates. We report the 90% confidence regions in the brackets below the point estimates. * – indicates significance at the 10% level, i.e., the 90% confidence region does not include 0. *** – indicates significance at the 1% level, i.e., the 99% confidence region does not include 0. The confidence regions were computed using subsampling without replacement: subsamples = 100, subsample size = 12 (out of 14) years.

Variables	(1) 1wb1da	(2) 1wb1da	(3) 1mb6ma	(4) 1mb6ma
v_{ij}	0.01	0.01*	0.16**	0.18**
	(0.01)	(0.01)	(0.06)	(0.08)
$MktVal_i$		-3.53e-07***		-2.23e-07
		(9.19e-08)		(1.23e-06)
$MktVal_j$		2.60e-07*		1.44e-06
		(1.46e-07)		(2.38e-06)
Observations	56	44	62	49
R-squared	0.02	0.08	0.09	0.12

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4: Merger Success Regressions (ordinary least squares with robust standard errors). Variable definitions: 1wb1da = cumulative fractional change (measured 1 week before the merger announcement date until 1 day after the merger announcement date) difference between the firm stock price performance and the general market (S&P 500) performance; similarly, 1mb6ma = cumulative fractional change (measured 1 one month before the merger announcement date until six months after the merger is confirmed) difference between the firm stock price performance and the general market (S&P 500) performance; v_{ij} = incremental pair specific merger value estimate; $MktVal_i$ = Market value for firm i at time of merger.

Appendix

Appendix A: Proofs and Computational Details

A1. Proof for Proposition 1.

Common Market Case: In the following, we concentrate on one common market and drop the market subscript m. Now, let the post-merger output be denoted by $q_{ij}^{PM} = (q_i + q_j - \epsilon) < q_i + q_j$, where $\epsilon = dq_{ij}^{PM} > 0$, and let the post-merger price be $P(\widetilde{Q})$ where $\widetilde{Q} = Q_{-ij} + q_{ij} + dQ$, with $dQ = \delta = \frac{dQ}{dq_{ij}^{PM}} dq_{ij}^{PM}$. For a merger to add value, the following equation has to apply:

$$\pi_{ij}^{PM} > \pi_i + \pi_j \iff P(\widetilde{Q})q_{ij}^{PM} - P(Q)(q_i + q_j) > TC(q_{ij}^{PM}) - (TC(q_i) + TC(q_j)) = \Delta TC_{ij}.$$

Remember that $\Delta TC_{ij} < 0$, and since $q_{ij}^{PM} < q_i + q_j$, this will also hold if there are post-merger synergies. Next, we can simplify the above expression to:

$$P(Q - \delta)(q_i + q_j - \epsilon) - P(Q)(q_i + q_j) > \Delta TC_{ij} \iff (P(Q - \delta) - P(Q))(q_i + q_j) - P(Q - \delta)\epsilon > \Delta TC_{ij}.$$

This can be rewritten as:[36]

$$dP * (q_i + q_j) - P(Q - \delta)\epsilon = dP * (q_i + q_j) - P(Q - \delta)\left|dq_{ij}^{PM}\right| > \Delta TC_{ij}.$$

Next, we recognize that $dQ < 0$ and that $\frac{dQ}{dQ} = 1$, so we can rewrite the equation above as:[37]

$$dQ\frac{dP}{dQ}(q_i + q_j) - P(Q - \delta)\left|dq_{ij}^{PM}\right| > \Delta TC_{ij},$$

multiplying both sides by $\frac{Q}{P(Q-\delta)Q}$:

$$dQ\left(\frac{dP}{dQ}\frac{Q}{P}\right)\frac{(q_i + q_j)}{Q} - \left|dq_{ij}^{PM}\right| > \frac{\Delta TC_{ij}}{P},$$

where $\left(\frac{dP}{dQ}\frac{Q}{P}\right)$ is the absolute inverse price elasticity of demand $\frac{1}{|\eta_{Qp}|}$. The above equation can further be rewritten as:[38]

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[36]Note that we take ϵ to represent an infinitesimal small change in the production of the merged firm and as such, $-\epsilon = -\left|dq_{ij}^{PM}\right|$ applies. We write this in terms of the absolute value to make it clearer what the sign of the terms are.

Also, since δ is taken to represent an infinitesimal small change in the market output, we take that $dP \approx \Delta P = P(Q - \delta) - P(Q) > 0$. Note that the equality holds strictly in the limit as $\delta \to 0$.

[37]Note, if all firms adjust to reestablish a Cournot equilibrium, then $\epsilon < \delta < 0$ will hold here. This follows from the Lemma provided in Farrell and Shapiro (1990: 111). However, if the outsiders are assumed to not respond to the change, then $\epsilon = \delta$.

[38]Note the negative sign within the parentheses results from: $\frac{dP}{dQ} = P'(Q) = \lim_{\epsilon \to 0}\frac{P(Q-\epsilon)-P(Q)}{(Q-\epsilon)-Q} = \lim_{\epsilon \to 0}\frac{P(Q-\epsilon)-P(Q)}{-\epsilon} =$

$$dQ\left(-\frac{(s_i + s_j)}{|\eta_{Q_p}|}\right) - |dq_{ij}^{PM}| = |dQ|\left(\frac{(s_i + s_j)}{|\eta_{Q_p}|}\right) - |dq_{ij}^{PM}| > \frac{\Delta TC_{ij}}{P}.$$

Dividing by $|dq_{ij}^{PM}|$:

$$\frac{|dQ|}{|dq_{ij}^{PM}|}\left(\frac{(s_i + s_j)}{|\eta_{Q_p}|}\right) - 1 > \frac{\Delta TC_{ij}}{P|dq_{ij}^{PM}|}.$$

Noting that $\frac{|dQ|}{|dq_{ij}^{PM}|} = \left|\frac{dQ}{dq_{ij}^{PM}}\right| = \left|\frac{dq_{ij}^{PM}}{dq_{ij}^{PM}} + \frac{dQ_{-ij}}{dq_{ij}^{PM}}\right| = |1 + \lambda_{ij}|$, where $\lambda_{ij} \leq 0$, and that $mr_{ij} = P * |dq_{ij}^{PM}|$
we have:

$$|1 + \lambda_{ij}|\left(\frac{(s_i + s_j)}{|\eta_{Q_p}|}\right) > \frac{\Delta TC_{ij} + mr_{ij}}{mr_{ij}}.$$

Scaling this result over the m common markets of firms i and j we get the result of Proposition 1. **QED.**

Non-Common Market Case: This case follows the same argument as that for the common market case. That is, suppose we are considering the non-common markets of i, where $q_{ij}^{PM} = q_i^{PM} = q_i - \epsilon$, then we arrive at the expression:

$$\pi_i^{PM} - \pi_i > 0 \iff |1 + \lambda_i|\left(\frac{s_i}{\eta_{Q_P}}\right) - \frac{\Delta TC_i + mr_i}{mr_i} > 0$$

where the terms are now defined as $\Delta TC_i = TC(q_i - \epsilon) - TC(q_i)$, $mr_i = P * |dq_i^{PM}|$, and $\lambda_i = \frac{Q_{-i}}{dq_i^{PM}}dq_i^{PM} < 0$. Summing this expression over all the non-common markets of i in $K_{i\neg j}$ yields the expression for non-common markets v_i used within the main text. The expression for v_j is derived the same way.

A2. Proof of Proposition 2:

While this proof is similar to that in Proposition 1, there are some important departures we illustrate here.

For notational simplicity, we again consider one market and omit the subscript m. Now, suppose that post-merger output is given by $q_{ij}^{PM} = (q_i + q_j + \epsilon) > q_i + q_j$, where $\epsilon = dq_{ij}^{PM} > 0$ and that the post-merger price is $P(\widetilde{Q})$, where $\widetilde{Q} = Q_{-ij} + q_{ij} + dQ$, with $dQ = \delta = \frac{dQ}{dq_{ij}^{PM}}dq_{ij}^{PM}$. A merger is profitable if:

$$\pi_{ij}^{PM} > \pi_i + \pi_j \iff P(\widetilde{Q})q_{ij}^{PM} - P(Q)(q_i + q_j) > TC(q_{ij}^{PM}) - (TC(q_i) + TC(q_j)) = \Delta TC_{ij}.$$

Note that $\Delta TC_{ij} > 0$ since $q_{ij}^{PM} > q_i + q_j$, and we have assumed no synergies.[39] Next, we can simplify

$(-1) * \underbrace{\lim_{\epsilon \to 0}\left(\frac{P(Q - \epsilon) - P(Q)}{\epsilon}\right)}_{positive}$. Hence, even though we are dealing with a decreasing change in output, the sign of the

elasticity of demand is as previously expected; however, we note that $dQ < 0$ here.

[39] Allowing for synergies may reverse this sign. That is, the presence of additional synergies may yield $\Delta TC_{ij} < 0$ even

this expression to:[40]

$$P(Q+\delta)(q_i + q_j + \epsilon) - P(Q)(q_i + q_j) > \beta \iff (P(Q+\delta) - P(Q))(q_i + q_j) + P(Q+\delta)\epsilon > \Delta TC_{ij},$$

$$\iff -dP * (q_i + q_j) + P(Q+\delta)\epsilon = -dP * (q_i + q_j) + P(Q+\delta)dq_{ij}^{PM} > \Delta TC_{ij},$$

multiplying both sides by $\frac{1}{dQ*Q}$ we get:

$$-\frac{dP}{dQ}\frac{(q_i + q_j)}{Q} + \frac{P(Q+\delta)}{Q}\frac{dq_{ij}^{PM}}{dQ} > \frac{\Delta TC_{ij}}{dQ * Q},$$

multiplying by $\frac{Q}{P(Q+\delta)}$:

$$-\left(\frac{dP}{dQ}\frac{Q}{P}\right)\frac{(q_i + q_j)}{Q} + \frac{dq_{ij}^{PM}}{dQ} > \frac{\Delta TC_{ij}}{P * dQ},$$

recognizing that $\frac{q_i}{Q} = s_i$ and that we have the price elasticity of demand:[41]

$$\left(\frac{s_i + s_j}{|\eta_{Q_p}|}\right) + \frac{dq_{ij}^{PM}}{dQ} > \frac{\Delta TC_{ij}}{P * dQ},$$

multiplying through by $P * dQ$:

$$\left(\frac{s_i + s_j}{|\eta_{Q_p}|}\right)(dQ * P) + dq_{ij}^{PM} * P > \Delta TC_{ij},$$

and dividing through by $\frac{1}{dq_{ij}^{PM}}$:

$$\left(\frac{s_i + s_j}{|\eta_{Q_p}|}\right)\left(\frac{dQ}{dq_{ij}^{PM}} * P\right) + P > \frac{\Delta TC_{ij}}{dq_{ij}^{PM}}.$$

Note that $\frac{dQ}{dq_{ij}^{PM}} = 1 + \frac{dQ_{-i}}{dq_{ij}^{PM}} = 1 + \lambda_{ij}$ where $\lambda_{ij} \leq 0$. Hence,

$$P * \left(1 + (1 + \lambda_{ij})\frac{s_i + s_j}{|\eta_{Q_p}|}\right) > \frac{\Delta TC_{ij}}{dq_{ij}^{PM}},$$

and noting that $mr_{ij} = P * dq_{ij}^{PM}$, we have:

$$(1 + \lambda_{ij})\frac{s_i + s_j}{|\eta_{Q_p}|} > \left(\frac{\Delta TC_{ij}}{P * dq_{ij}^{PM}} - 1\right) = \left(\frac{\Delta TC_{ij} - mr_{ij}}{mr_{ij}}\right).$$

---

when $q_{ij}^{PM} > q_i + q_j$.

[40]As previously noted, if all firms adjust to reestablish a Cournot equilibrium, then $\epsilon > \delta > 0$ due to the Lemma provided in Farrell and Shapiro (1990: 111).

[41]Note: $\left(\frac{dP}{dQ}\frac{Q}{P}\right) = 1/\left(\frac{dQ}{dP}\frac{P}{q}\right) = \frac{1}{\eta_{Q_p}} = -\frac{1}{|\eta_{Q_p}|}$

Scaling this result over the m common markets of firms i and j, we get the result of Proposition 2. **QED.**

Non-Common Market Case: Again, this case follows the same argument as that of the common market case above, yielding the expression:

$$\pi_i^{PM} - \pi_i > 0 \iff (1+\lambda_i) \left(\frac{s_i}{|\eta_{Q_P}|} \right) - \frac{\Delta TC_i - mr_i}{mr_i} > 0$$

where the terms are now defined as $\Delta TC_i = TC(q_i - \epsilon) - TC(q_i)$, $mr_i = P * \left| dq_i^{PM} \right|$, and $\lambda_i = \frac{Q_{-i}}{dq_i^{PM}} dq_i^{PM} <$ 0. Summing this expression over all the non-common markets of i in $K_{i\neg j}$ yields the expression for the non-common markets v_i used within the main text. The expression for v_j is derived similarly.