The Impact of Horizontal Mergers on Market Structure: Evidence from the Semiconductor Industry

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Abstract

The U.S. and EU Merger Guidelines strongly emphasize the relevance of the “ease of entry” argument in merger evaluations. Up to now, very little is known empirically about how mergers affect entry and exit, and the resulting number of firms in the markets. We empirically test this aspect of mergers using a comprehensive database that contains detailed firm-level information on mergers, production, and innovation in the dynamic random access memory semiconductor market from 1985 to 2004. Our reduced-form regression results show that mergers dominated by efficiency effects have a negative impact on the number of firms in the product market. Mergers dominated by market power effects result in a higher number of firms than efficiency dominated mergers. Interestingly, we also find that mergers foreclose potential entry in other product markets and reduce the number of firms in related product markets. Finally, our results confirm that postmerger changes in the equilibrium number of firms directly impact market prices.

JEL-Codes: L110, L130, L520, O310, O320, O380.

Keywords: competitive effects, entry, foreclosure, horizontal mergers, market structure.

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1 Introduction

Merger policy is one of the most active areas of antitrust policy. The U.S. and the European Union prohibits mergers that substantially lessen competition, see Section 7 of the Clayton Act (as amended by the Celler-Kefauver Act) and the EU Merger Regulation (EC) No. 139/2004. The Horizontal Merger Guidelines provide guidance in evaluating the potential anticompetitive effects of mergers. The Guidelines explicitly say that for a merger to be permitted, merger-specific efficiency gains must be sufficiently high to compensate for the anticompetitive market power effects of the merger and to cause postmerger prices to decline.[1]

Beyond evaluating merger-specific efficiency and market power effects in the short run, several scholars and policy makers emphasized the relevance of accounting for efficiency gains triggered by postmerger entry.[2] If the industry was in equilibrium before the merger, the merged firm may be replaced by another firm entering the market, such that the pre-merger equilibrium number of firms and prices are restored. Moreover, the Merger Guidelines recognized the relevance of postmerger entry and explicitly state that entry can mitigate the anticompetitive market power effects of a merger. More specifically, the U.S. and EC Merger Guidelines strongly emphasize the relevance of considering the "ease of entry" argument in merger evaluations (see Section 9 of the U.S. Department of Justice and U.S. Federal Trade Commissions Horizontal Merger Guidelines (August 19, 2010) and Section VI of the European Commissions Guidelines on the Assessment of Horizontal Mergers (February 5, 2004)). The Merger Guidelines refer to whether entry will be likely, timely, and sufficient to prevent the potential anticompetitive effects of a merger. The Guidelines define entry to be timely if it occurs within two years, see Section 3.2 in the U.S. Horizontal Merger Guidelines (1992, revised 1997 and 2010) and Paragraph 74 in the

[1] A merger eliminates an incumbent firm from the market, which reduces competition in the product market and results in higher postmerger prices, also referred to as the "market power effect". Mergers can achieve synergy or efficiency gains, which have a counter-effect on prices if the efficiency gains are passed on to consumers, also called the "efficiency effect". Merger-specific synergies are among the most important criteria to evaluate the potential beneficial impact on postmerger consumer welfare. Prominent contributions in this area are Stigler (1950), Williamson (1968), Salant, Switzer, and Reynolds (1983), Davidson and Deneckere (1985), Perry and Porter (1985), and Farrell and Shapiro (1990), among many others. For further contributions on merger control and the impact of mergers on firm and market performance, see also Gugler, Mueller, Yurtoglu and Zulehner (2003), Goetz and Gugler (2006), Miller and Weinberg (2015), Miller, Remer, Ryan, and Sheu (2016), Duso, Gugler, and Szuecs (2013), and Duso, Gugler, and Yurtoglu (2011) as well as the literature cited therein.

[2] Carlton (2007) notes that "...by focusing only on efficiencies that influence price over a short period, a government antitrust agency risks failing to credit the future efficiencies [via changes in market structure] that will benefit consumers in the long run."

European Commissions Guidelines on the Assessment of Horizontal Mergers.[3] Even though the U.S. courts have rejected several merger challenges on the grounds that merger would trigger entry and prevent any postmerger anticompetitive effects, there is surprisingly little empirical evidence on the impact of mergers on entry, and we need more insight on this important topic.[4] The main objective of our study is to evaluate the impact of mergers on the number of firms and prices while explicitly distinguishing between efficiency and market power dominated mergers.

The question that frequently arises is why we would observe entry after merger even though it was not observed before the merger. The Merger Guidelines are explicit about the fact that pre- and postmerger market conditions are different, see also the discussion in Baker (2003). If a merger generates dominant market power effects, industry output is lower (merging firms restrict output and, although non-merging incumbents expand output, there is still a net reduction in industry output) and prices are higher post merger, which leaves sales opportunities for an entering firm after merger beyond what had been available prior to the merger. Therefore, entry may be profitable after a merger even if it had not been profitable before the merger. Therefore, a replacement of the merged firm by an entering firm is feasible and might mitigate the market power effect from merging. Hence, even though mergers generate dominant market power effects, they may provide entry opportunities and restore pre-merger prices.

Several theoretical merger studies concentrated on free entry and elaborated on an interesting point, i.e., that postmerger entry is more likely if mergers are dominated by market power effects rather than by efficiency effects, see, e.g., Cabral (2003), Spector (2003), Davidson and Mukherjee (2007), and Werden and Froeb (1998). The reason is that efficiency dominated mergers result in lower prices and leave fewer profits for entrants, which makes entry less profitable. Moreover, efficiency dominated mergers can drive incumbent firms out of the market and reduce the postmerger number of firms even further. Consequently, an interesting conflict arises in comparing efficiency defense and the ease of market entry arguments: While mergers dominated by market power effects increase prices, they provide entry opportunities which causes downward pressure on prices. The question is whether market power mergers attract sufficient entry such that pre-merger equilibrium prices are at least restored. In contrast, efficiency dominated

[3]The entry section in the 1992 Horizontal Merger Guidelines was substantially revised, see Baker (2003) and Shapiro (2010) for more details.

[4]For further information, see also Werden and Froeb (1998) and Baker (2003).

mergers will reduce prices, but will make entry more difficult and even cause incumbent firms to exit, such that postmerger prices in the long run could be even higher than pre-merger prices or resulting postmerger prices caused by market power mergers. It is important to recognize that the efficiency argument and the ease of entry argument can work in opposite directions when evaluating entry and the associated impact on prices. This controversial argument supports the importance of gaining further insight into the impact of mergers on market structure and prices. Our study also accounts for foreclosure effects, i.e., whether mergers are used by acquirers as an instrument to foreclose potential entry of target firms into related product markets that an acquirer operates in. This can result in a lower postmerger number of firms and increases postmerger prices in those related product markets.[5]

We empirically test the impact of mergers on the number of firms and postmerger prices using a comprehensive database that contains detailed firm-level information on mergers, production, and innovation in the dynamic random access memory semiconductor market from 1985 to 2004. Our reduced-form regression results provide interesting insights regarding postmerger changes in market structure and prices. We find that mergers reduce the number of active firms in the corresponding product market. Interestingly, mergers dominated by efficiency effects have a more negative impact on the number of firms in the product market compared to mergers dominated by market power effects. Our results show that mergers also reduce the number of firms in related markets, due to the fact that mergers foreclose potential entry in other product markets. Finally, our results confirm that postmerger changes in the equilibrium number of firms have a direct impact on prices.

The remainder of the paper is organized as follows: Section 2 introduces the industry and the data and provides summary statistics. In Section 3, the empirical model is introduced, and Section 4 presents the empirical results. We conclude in Section 5.

[5] To the best of our knowledge, we are aware of only one empirical study by Berger et al. (2004) that evaluates the impact of mergers and acquisitions on entry. This study is distinct from ours in several aspects. Our study directly concentrates on the role that market power and efficiency arguments play regarding the conflict in comparing the efficiency defense and the ease of market entry arguments. We explicitly consider a distinct impact of mergers depending on those two arguments. Moreover, we consider multi-market competition effects and evaluate if mergers can foreclose potential entry in other product markets. Finally, they focus on the banking industry which is marked by local competition and little innovation. Our study concentrates on the semiconductor industry which differs from banking since it is one of the most intensive high tech industries and characterized by international production. The impact of mergers on market structure is an empirical question and further insight is needed for different industries.

2 Industry and Data Description

The semiconductor industry is an important industry that promotes productivity and growth. Semiconductor chips are key inputs in consumer goods, computers, telecommunication products, industrial instruments, and medical equipment. We concentrate on dynamic random access memory (DRAM) chips, which are electronic product inputs that store information in binary form. Our data cover firm-level production, innovation, and merger information on the DRAM industry from 1985 until 2004. The DRAM market is a natural setting to study postmerger entry and exit for several reasons. First, mergers are an important instrument in this market, and a large number of mergers have taken place in the industry. Second, our database contains detailed firm-level production data at a highly disaggregate product-market level, i.e., the DRAM chip market. This allows us to properly define horizontal mergers between producing firms in the same product market. Moreover, it allows us to observe entry and exit at a highly disaggregate product-market level and eventually enables us to evaluate the postmerger impact on market structure in the same product market and in related product markets. Third, the detailed firm-level production data enables us to get reliable information on firms' entry and exit, as well as the number of active firms in the product market. We do not have to rely on aggregate sales data taken from firms' balance sheets, which do not reflect firms' market presence at a highly disaggregate product-market level. Fourth, the availability of detailed firm-level production data also enables us to distinguish between mergers dominated by market power and efficiency arguments, as will be discussed later. Hence, we do not have to rely on transaction prices, which are frequently unobserved. Fifth, the industry is characterized by a decent amount of entry and exit, which ensures a sufficient large amount of variation in the number of firms. Sixth, the industry is not highly concentrated, which is an advantage in our study, since firms are less concerned that proposed mergers would fall under antitrust scrutiny, which avoids potential selection issues. Finally, a large fraction of firms operate in two distinct product markets, i.e., the DRAM and flash memory product markets.[6] This fact enables us to evaluate to what extent mergers foreclose potential entry in related product markets. More specifically, we can assess to what extent mergers in the flash memory market have an impact on the number of firms in the

[6]Note, that DRAM and flash memory chips are distinct in regards to fundamental data information storage capabilities. Therefore, the chips serve different purposes and characterize separate product markets.

DRAM market, due to the fact that such mergers reduce the number of potential entrants for the DRAM market.

The data were collected from a variety of sources. Gartner, Inc. provided the production database, which includes worldwide DRAM-producing firms and covers quarterly firm-level DRAM production information from 1985 to 2004. The information on mergers is taken from the Thomson Financial Securities Database, which includes mergers with deal values of more than $1 million. We concentrate on horizontal mergers, as this allows us to closely relate to the Horizontal Merger Guidelines. We have data on horizontal mergers in the DRAM and flash memory market. Finally, we use patent information at the firm level. The patent information was procured from the U.S. Patent and Trademark Office (USPTO), and we retrieved patents that have been applied for and subsequently granted.[7] Patent information such as the date when the inventor applied for the patent, the date when the patent was granted, the assignee, and the patent or technology classes was included. Based on the technological classification of the patents, we are able to identify the DRAM patents at the firm level.[8]

Table 1 shows that DRAM production significantly increased from 704 million units in 1985 to 5.4 billion units in 2004. This fact is explained by the increasing demand and the relevance of DRAM chips for electronic products such as laptops, tablets, cell phones, game consoles, etc. On average, 19 DRAM-producing firms are active in the market. The industry is characterized by relatively large amounts of entry and exit. Over the sample period, 27 firms entered and 32 firms exited the DRAM market entirely. The high entry and exit rates are favorable for our purpose of identifying the impact of mergers on market structure. Note that, higher entry rates are positively correlated with higher exit rates, providing evidence for the competitiveness of the DRAM market. The average market share of a firm is 5.83 percent. The average market share of a firm right before exiting an industry is 3.17 percent while the average market shares of continuing firms at the corresponding time periods are 5.42 percent. Hence, smaller firms exited and larger firms were more likely to stay in the market.

[7] The patent information is contained in the National Bureau of Economic Research (NBER) patent database. A large name-matching effort was undertaken to match the names of patenting organizations and the names of manufacturing firms, including 30,000 of their subsidiaries (obtained from the *Who owns Who* directory). The U.S. is the world's largest technology market, and non-U.S. based firms also frequently file for patents in the U.S.

[8] The USPTO has developed a highly elaborate classification system for the technologies to categorize the patented inventions consisting of about 400 main (three-digit) patent classes. Patent examiners from the USPTO provided the technological classes that refer to most DRAM-related patents.

Having a closer look at market shares of surviving firms, Figure 1 shows that market shares are delineated by strong variation over time. Figure 2 illustrates that market shares of exiting firms frequently show a downward trend over time. Moreover, in comparing market shares of surviving and exiting firms, the figures support the previously mentioned fact that exiting firms are characterized by low market shares at the time of exit.[9] The variation in number of firms, entry and exit, and market shares across firms and over time is beneficial for our purposes since our identification will come from variation across firms and across time periods.

As shown in Table 2, 47 firms produced DRAM chips at some point during the time period, and 32 firms were active in the flash memory industry at some point. Interestingly, a large proportion of those producing firms (50%) were active in both markets, confirming a high degree of multimarket competition. It should be noted that firms' multimarket presence is not significantly different between surviving and exiting firms in the DRAM industry. In both cases, around 50 percent of the DRAM firms also compete in flash memories. These facts highlight that multimarket competition is an important feature among DRAM-producing firms.

As shown in Table 1, firms engaged in 14 horizontal mergers, of which eight mergers occurred in the DRAM market and six mergers were performed in the Flash market.[10] Table 1 shows that merger activity in DRAM and flash markets are accompanied by higher entry and exit rates in the DRAM market. Moreover, it should be noted that the Herfindahl-Hirschman Index (HHI) concentration measure strongly increases after 1998 when several DRAM and flash mergers took place. Also, the HHI is below the critical thresholds mentioned in the Merger Guidelines, which works in our favor since it ensures that we observe market power dominated mergers. If the HHI were above the critical levels, market power mergers would most likely have been blocked by antitrust authorities. It is interesting to note that out of the eight mergers in the DRAM market, four mergers were among firms that were present in both the DRAM and the flash memory product markets, confirming the merging firms' multimarket presence. Out of the remaining four mergers, three were characterized by one merging firm being active in both product markets. This fact emphasizes the potential foreclosure effect on entry in related product markets.

[9] For illustrative purposes, Figures 1 and 2 include firms that survived for at least two years in the DRAM market.

[10] Given the highly disaggregate product-market level we concentrate on, we are able to consider a relatively large number of mergers.

As mentioned in the introduction, it is reasonable to expect that mergers dominated by market power effects have a different impact on entry and exit than mergers dominated by efficiency effects. Therefore, we distinguish between mergers dominated by market power effects and mergers dominated by efficiency effects. In following Farrell and Shapiro (1990), we distinguish between market power (efficiency) dominated mergers if the postmerger market shares of the merged entity are smaller (larger) than their premerger market shares.[11] Farrell and Shapiro (1990) focus on oligopolistic markets and use general demand and cost functions and show that if a merger generates no synergies and is driven by market power arguments, then it causes prices to rise, see their Proposition 2. Merging firms will contract their aggregate output to internalize the inframarginal losses they impart to each other. Nonmerging firms respond with output expansions, this is outweighed by the output contraction of insiders since reaction functions imply smaller responses for rivals. Hence, a market power dominated merger will cause merging firms to lower market shares. In contrast, in efficiency dominated mergers, the firm faces substantially lower marginal costs than did its constituent firms which increases the postmerger firm's market shares. Keeping in mind that reaction functions describe smaller responses in magnitude for rivals, a sufficient condition for postmerger prices to decline is that insider market shares increase due to sufficient efficiency effects of the merger. The classification suggested by Farrell and Shapiro (1990) are useful in our context since the memory chip market that we concentrate on in our study shares similar characteristics to the model assumptions made by Farrell and Shapiro (1990), i.e., memory chip vintages that are relatively homogeneous, see also Zulehner (2003) and Siebert (2010). We distinguish between market power and efficiency mergers in our dataset by comparing merging firm's premerger market shares with their postmerger market share one year after merger formation.[12] We categorize the eight DRAM mergers into four market power mergers and four efficiency mergers. We introduce a dummy variable $MPMerger^D$ that takes on a value of 1 if the merger was dominated by market power effects, and a superscript D refers to the DRAM market. Table 1 shows that market power mergers took place from 1998 to 2001.

Table 3 shows merging and nonmerging firms' market shares (MS^D) and patents ($Patents^D$)

[11] See also Duso et al. (2014). Gugler and Siebert (2007) have shown that this relationship also applies with any degree of product differentiation.

[12] The classification into market power and efficiency mergers is robust to using insiders' postmerger market shares two years after merger formation.

in the DRAM market over time, measured in quarters, i.e., one year before merging ($t^* - 4$), at the time of merging (t^*), one quarter after merging ($t^* + 1$), one year after merging ($t^* + 4$), and two years postmerger (t^*+8).[13] Interestingly, the market shares and patents are not significantly different from each other at the 90 percent confidence interval. Moreover, the time series for the market shares and patents of merging and nonmerging firms evolve similarly post merger. The data support the fact that merging firms do not select themselves into mergers based on these information.

Figure 3 shows the evolution of each merging firms' market shares in the DRAM market at the time of merging (t^*), one quarter after merging ($t^* + 1$), one year after merging ($t^* + 4$) and two years after merging ($t^* + 8$). In order to better relate merging firms' to nonmerging firms' market shares, we use the difference between the merging firms' market shares in period t ($MS^D_{m,t}$) and the average of other nonmerging firms' market shares ($AvgMS^D_t$). The subscript m corresponds to the merging firms. Several aspects of Figure 3 are interesting to note. First, while postmerger market shares increase for some merging firms (compared to other nonmerging firms), they decline for other merging firms. This finding provides support for finding both types of mergers in the market, i.e., market power and efficiency dominated mergers. Second, it should be noted that the increasing or decreasing trend in market shares is strictly monotonic. This confirms the notion that our classifications into market power and efficiency mergers are robust to evaluating the postmerger impact on market shares one year (t^*+4) or two years (t^*+8) after merger formation. Third, in two (six) out of the eight mergers, merging firms' market shares are higher (lower) at the time of merger formation compared to other firms' market shares in the industry. This fact supports the notion that there is no systematic selection on market shares into mergers. The same argument applies if we concentrate on market power dominated or efficiency dominated mergers only. Both types of mergers are formed among firms whose premerger market shares can be smaller or larger than nonmerging firms, which leads to the conclusion that firms do not select themselves into mergers based on their market shares.

Figure 4 shows the difference in the number of DRAM patents between merging and nonmerging firms over time. The figure shows that around 50 percent of merging firms possess more patents than nonmerging firms and vice versa. In terms of the impact over time, as expected,

[13] t^* corresponds to the period when the merger took place. Note that, the nonmerging firms' market shares are selected at specific time periods that match the time period of the merging firms market shares under consideration.

the figure illustrates that mergers have a slower impact on DRAM patents compared to market shares.

After removing observations characterized by missing values, our final dataset consists of 44 firms, and each firm is observed on average for approximately 35 periods, which leaves us with $1,532$ observations.

3 The Empirical Model

The reduced-form specification of our empirical model can be derived from a firm's supply relation in a standard Cournot oligopoly model with quite general demand and cost functions, such as Farrell and Shapiro (1990).[14] Therefore, the number of firms present in the DRAM market (N_t^D) is defined as a function of firms' efficiency levels, output and concentration measures as well as merger dummy variables. The empirical model is specified as follows:

$$N_t^D = \beta_1 PS_{i,t-1}^D + \beta_2 ACCQ_{i,t-1}^D + \beta_3 Q_{-i,t-1}^D + \beta_4 q_{i,t-1}^D + \beta_5 HHI_{t-1}^D + \beta_6 Merger_{t-1}^D$$

$$+\beta_7 MPMerger_{t-1}^D + \beta_8 Merger_{t-1}^F + \epsilon_t^D, \qquad (1)$$

where the subscripts i and t refer to the firms and time periods measured in quarters. Note that the unit of analysis for the number of firms (as well as mergers) is specified at the industry-level in quarters. Based on a firm's underlying supply relation, the number of firms is explained by several firm-level information defined at the firm-level in quarters, such as $PS_{i,t-1}^D$, which refers to the firm's DRAM patent stock. It captures firms' innovation activities and controls for firms' efficiency levels, since higher innovation reduces firms' production costs. As an additional control for firms' marginal costs, we relate to previous studies in the engineering, economics, and management literature that provide evidence for significant learning-by-doing effects in the DRAM market.[15] In following previous studies, we account for learning-by-doing using firms'

[14] An example is provided in the Appendix. Note, that a fully structural dynamic oligopoly model would face several challenges and limitations especially with regard to incorporating a merger formation process into a dynamic framework. For further information on merger formation in a matching framework, see also Linde and Siebert (2016).

[15] In fact, firms achieve significant cost savings by improving their production process with regard to reducing dust, vibration levels, and the size of the wafers, among other aspects. This often allows firms to increase yield rates from as low as 20% to more than 90%.

accumulated production over time ($ACCQ^D_{i,t-1} = \sum_{s=1}^{t-1} q^D_{i,s}$). Hence, learning-by-doing effects increase with a higher production experience, which reduces firms' marginal costs. We also include firms' output measures such as other firms' output $Q^D_{-i,t-1}$ and firm i's output $q^D_{i,t-1}$ As additional explanatory variable, we include the Herfindahl-Hirschman Index (HHI^D_{t-1}) to control for different levels of concentration in the industry. In order to measure the impact of a merger in the DRAM industry on the number of firms in the same industry, we formulate a dummy variable $Merger^D_{t-1}$ that takes a value of 1 if a DRAM merger takes place in period $t-1$, otherwise the dummy is zero.[16] Note that mergers have a contemporaneous impact on market structure by definition since two merging firms reduce the number of firms in the market from N^D_t to $(N-1)^D_t$, and the merger dummy would imply a negative coefficient. If the merged firm is replaced by another entering firm, we do not expect a change in the number of firms due to merger. If the merger attracts additional entrants, we expect the merger dummies to have positive coefficients. As shown in equation (1), we measure the impact of mergers on market structure allowing for a market structure response of one quarter. In accordance and recommendations with the merger Guidelines (as mentioned in the introduction), we evaluate the impact of mergers on market structure one and two years after merger formation. We also include the dummy variable $MPMerger^D_{t-1}$ to control for differential impacts between market power mergers and efficiency mergers on market structure. We expect the dummy to have a positive impact on the number of firms if market power mergers attract more entry relative to efficiency mergers. The parameter estimate on the dummy variable takes on a negative value if efficiency mergers do not offer incentives for firms to enter or drive incumbent firms out of the market. Again, we test the impact of those mergers for up to two years after merger formation. Finally, we analyze the impact of mergers on the number of firms in related product markets. Hence, we measure to what extent the number of firms in the DRAM market would be affected by mergers in the flash memory market measured by the dummy variable $Merger^F_{t-1}$. We thoroughly discuss potential simultaneity and heterogeneity issues using an instrumental variable approach in the empirical section later.

Next, we evaluate the extent to which postmerger changes in the number of firms eventually affect postmerger prices. Beyond this aspect, we are also interested in testing whether mergers

[16] The formulation of a dummy variable is appropriate in our context since at most one merger per quarter has been formed.

exert further impacts on price, possibly explained by changes firms' conduct in the market, e.g., firms become more aggressive postmerger and invest more in advertisement, product innovation etc. Hence, we test if mergers might exert any remaining direct impact on price that would not be captured by the pre- to postmerger changes in the number of firms. For this purpose, we estimate an inverse demand equation and adopt the following specification similar to previous studies on the DRAM industry, see, e.g., Siebert (2010) and Zulehner (2003) among others:

$$log(P_t^D) = \gamma_0 + \gamma_1 * log(Q_t^D) + \gamma_2 * NOF_t^D + \gamma_3 * GDPEL_t + \gamma_4 * Merger_{t-1}^D + e_t, \qquad (2)$$

where $log(P_t^D)$ is the log of the price in the DRAM industry and $log(Q_t^D)$ is the log of the industry output.[17] Hence, we control for postmerger changes in equilibrium output having an impact on price. NOF_t^D is the number of firms and $GDPEL_t$ is the GDP in electronics, which controls for demand shifts. We also include the lagged merger dummy ($Merger_{t-1}^D$) which tests whether mergers exert any remaining direct effect on price or if the changes in market structure are sufficient arguments to explain postmerger changes in price. To avoid a potential simultaneity bias, we apply an instrumental variables approach, which will be explained in the next section.

4 The Results

When estimating equation (1), we have to be aware that firm quantities are endogenously chosen. The reason is that firms adjust their firm-level production to demand shocks observed by the firm but not by the econometrician. This contemporaneous correlation between the error term and a firm's production causes a potential simultaneity bias. To avoid this potential bias, we follow Berger et al. (2004) and use the lagged (i.e., two-period lag) variables that contain firm-level production as instruments.[18] To further avoid the criticism that time-invariant firm effects could determine a firm's production, we use the traditional instruments suggested in the economics literature to explain firm-level quantities, i.e., wages, material price for silicon (which

[17] Remember that, the unit of observation is measured in quarters t. The price is deflated to 1985 dollars, which is the initial year of our dataset.

[18] Using lagged variables is commonly applied in panel data studies. We also tested for the fact that no remaining autocorrelation is present in our residuals.

is the main input for semiconductors), and the producer price index.[19] We also use past accumulated firm-level output as an instrument, which measures firms' production experience and controls for firms' marginal cost changes due to learning-by-doing effects. Finally, as commonly employed in the economics and panel data literature, we use further lags of q^D, Q^D and HHI^D as instruments.

Turning the potential endogeneity of the merger dummy, it is important to note that the merger decision is formulated at the firm-level, while the error term (ϵ^D) captures industry-wide shocks rather than firm-level shocks. In this context, also recall that we observe, at most, one merger per quarter, see Table 1. Therefore, merger activity in the DRAM industry is distributed across different periods, not concentrated within a few periods. Our data rule out concerns that firms' merger decisions could potentially be correlated with industry-wide trends entering industry-wide shocks, such as merger waves, and mergers driven by financial market conditions, etc. Also, the merger variable is lagged by one period, which diminishes the potential contemporaneous correlation issue with the industry-wide shock ϵ^D. To apply further robustness checks and to avoid any remaining potential concerns, we also estimated specifications in which the merger dummies are lagged by further (up to eight) periods, and our findings remain robust.

One might still raise the concern that a potential longer lasting heterogeneity problem could cause truncation or selection problems. However, our descriptive statistics in Table 3 provide evidence that neither market shares nor patents are significantly different between merging and nonmerging firms. This leaves us to conclude that potential truncation issues are not severe. Finally, we applied a propensity score technique to test for potential truncation issues, and it did not significantly change the magnitude of the merger impact.[20]

We estimate equation (1) applying a two-stage least squares (2SLS) instrumental variable approach. The results are shown in Table 4, which reports robust standard errors. Column 1 shows the estimation results as described in equation (1).[21] Columns 2 and 3 show the results for measuring a longer-run impact on the number of firms in period $t+4$ and $t+8$ (i.e., N^D_{t+4}

[19]Wages in the semiconductor industry are taken from the *Yearbook of Labor Statistics* (1988-2006). The material price of silicon can be found at the following Web page: "http://minerals.usgs.gov/minerals/pubs/commodity/silicon/". The producer price index is taken from the Bureau of Labor Statistics.

[20]I would like to thank an anonymous referee for suggesting the last two points.

[21]Remember that, our dataset includes 44 firms observed for approximately 35 periods, which explains the 1,532 observations.

and N^D_{t+8}), respectively.[22] The first-stage estimation results support a good fit, with adjusted R-squares of 0.81 and higher for the three different specifications (as shown in Columns 1-3). We test for the necessity of using instruments and apply Hausman tests for the three different specifications. The F-values indicate that 2SLS is preferred over ordinary least squares (OLS) at a 5% level of significance. The Hausman statistic confirms the necessity of using an instrumental variables method rather than a more efficient OLS estimation.[23] We also apply a Durbin-Wu-Hausman test, and the corresponding F- values confirm the validity of our instruments, i.e., OLS is not consistent, and we can reject the exogeneity of quantities.

Regarding the second-stage results, most interesting in our context is the significantly negative coefficient for the $Merger^D$ variable, which provides evidence that a DRAM merger reduces the number of firms in the DRAM market by three, see Column 1. The estimate for the market power merger dummy variable ($MPMerger^D$) is significantly positive, confirming the fact that market power dominated mergers increase the number of firms by one compared to efficiency dominated mergers. Hence, while efficiency dominated mergers formed in the DRAM industry reduce the number of firms in the DRAM industry by three, market power mergers increase the number of firms relative to efficiency mergers, or, market power mergers reduce the number of firms by only two. It should be noted that both types of mergers would reduce the number of firms beyond the one-firm reduction that is inherent in the merger firms *per se*. This result supports the notion that merging firms would be able to drive out other firms. The finding that efficiency mergers reduce the number of firms to a higher degree than market power mergers is also interesting since this comparison between pre- and postmerger equilibrium number of firms allows us to draw inferences about whether mergers predominantly generated cost efficiencies or market power effects. This identification of merger dominated by market power and efficiency effects is somewhat similar to Farrell and Shapiro (1990) who suggested to compare the changes of the sum of the merged firms' market shares pre- and postmerger, as described earlier.

Turning to the parameter estimate of our flash merger dummy ($Merger^F$), the negative coefficient shows that a merger in the flash market reduces the number of firms in the DRAM market by one. This result provides evidence that mergers have an impact on the number of

[22] Due to the redefinition of N^D_t to N^D_{t+4} and N^D_{t+8}, the number of observations reduced to $1,329$ and $1,226$ in Columns 2 and 3, respectively.

[23] The OLS estimation results are available from the author upon request.

firms in related markets, supporting the notion that the impact of mergers on the number of potential entrants matters.

The estimated coefficient for $ACCQ^D$ is significantly negative, supporting the fact that a higher accumulated industry output translates into more learning-by-doing, which affects marginal costs and the number of firms. The coefficient for output of all other firms (Q^D_{-i}) is significant and has a positive impact on the number of firms, as predicted by equation (4). However, the coefficient on firm-level production (q^D_i) is not significant.

We now turn to discussing the estimation results for measuring the merger impact on the number of firms in period $t{+}4$ and $t{+}8$, as shown in Table 4, Columns 2 and 3, respectively. Most estimation results are comparable to the previous results in terms of magnitude and efficiency. It should be noted that the estimates for the merger dummies ($Merger^D$ and $Merger^F$) become even more negative, emphasizing a higher impact on firm exit in the more distant future.[24] We apply several robustness checks. First, we exclude the firm-level production variable (q^D_i) since this is the most critical variable that might cause a potential simultaneity bias. We estimate the modified equation (1) using the same instruments. The results are not very different than those reported in the previous regressions, which confirms the robustness of our results, see Table 5. Second, we estimate equation (1) using a nonlinear instrumental variable Poisson regression model. Hence, we account for the fact that the response variable (N) is discrete with a distribution that places probability mass at non-negative integers only. We formulate a nonlinear count data model and estimate the regression equation applying a general method of moments estimator using the same set of instruments as before. Table 6 shows the estimates along with the robust standard errors. The estimation results confirm our previous findings. Third, we estimate a negative binomial model to address the common critique and fundamental problem with the Poisson model-that the model assumes equality of the variance and the mean. Since most count data are characterized by a variance usually exceeding the mean, it potentially suffers from overdispersion. Even though there is no reason to assume that our data suffers from this overdispersion problem, we still test for potential overdispersion. The estimation results of the negative binomial model confirm that the overdispersion parameter is zero. Another common problem with Poisson models is that the probability of a zero count is predicted to be

[24] This result has to be interpreted cautiously, however, since it might well be that the larger effect is explained by several consecutive mergers having an impact on the number of firms in the future.

lower than actually observed in the data. Compared to most other count data studies, this is not much of a problem in our application, as we hardly observe zero counts.

We now discuss the estimation results of our inverse demand equation (2).[25] We account for the potential endogeneity of industry quantity and use the following supply shifters as instruments: wages, material price for silicon, the producer price index, and past accumulated industry output ($ACCQ^D$), which measures industry-wide learning effects. The 2SLS estimation results are shown in Table 7, Column 1. The table reports robust standard errors. We find a significantly negative coefficient of industry output (Q^D), which confirms the negative slope of the inverse demand. The corresponding price elasticity of demand is -2, which is relatively elastic and similar to what previous studies found, see e.g., Siebert (2010) and Zulehner (2003). The significantly negative coefficient of the number of firms (NOF^D) provides evidence that a larger number of firms increases competition and reduces price. This result is supported by standard economic models and empirical studies on market structure. On average, an additional firm decreases the price by 5 percent. Applying this finding to the fact that efficiency (market power) mergers reduce the postmerger number of firms by three (two), this results in a postmerger price increase of 15 percent for efficiency dominated mergers and 10 percent for market power dominated mergers. Note that our intention was to isolate the impact of the postmerger changes in market structure (i.e., changes in the number of firms) on prices from other causes associated to mergers that might have an impact on prices such as changes in firms' conduct in the market. Our results confirm that postmerger price changes are sufficiently explained by the associated change in the number of firms, rather than other merger related arguments. The estimate for the GDP in electronics ($GDPEL$) confirms that a higher GDP shifts the inverse demand outward. The first-stage R-squares are higher than 0.4, and the Durbin-Wu-Hausman test confirms that the validity of our instruments. As a robustness check, we also estimated a modified version of equation (2) in which we replaced the industry output ($log(Q_t^D)$) with the lagged industry output ($log(Q_{t-1}^D)$). The results are not significantly different, as shown in Table 7, Column 2.

[25] Remember, the unit of observation is measured in quarters.

5 Conclusion

In evaluating the postmerger impact on prices, we address the following interesting conflict between the efficiency argument and the ease of entry argument: While market power dominated mergers increase prices, they are more likely to attract more postmerger entry imposing downward pressure on the price. In contrast, efficiency dominated mergers reduce postmerger prices, but drive incumbent firms out of the market which and leave fewer profits for entrants such that fewer firms enter postmerger. The ultimate impact of efficiency and market power driven mergers on market structure and price is therefore an empirical question.

Based on a comprehensive dataset that encompasses detailed firm-level information on mergers, production, and innovation in the DRAM market, we find that mergers dominated by efficiency effects reduce the number of firms in the product market to a larger extent than market power mergers. Hence, our study shows that market power mergers attract realtively more entry than efficiency dominated mergers. Therefore, efficiency dominated mergers may result in higher postmerger prices than market power mergers. Consequently, against the background of entry, efficiency generating mergers that reduce the number of firms in the market are not necessarily more beneficial than market power mergers that are followed by entry. Moreover, our results provide evidence that mergers reduce the number of firms in related product markets, which confirms the notion that mergers foreclose potential entry into other product markets. Hence, we show that mergers can have a significant impact not only on market structure in the product market under consideration, but also in related product markets. Finally, our results show that mergers have an impact on postmerger prices via postmerger changes in the number of firms. Therefore, the pre- and postmerger changes in the number of firms allow us to draw inferences about whether mergers were dominated by market power or efficiency effects. This is similar to the argument that has been made by Farrell and Shapiro (1990) in determining the impact of mergers on prices by comparing the pre- and postmerger changes in equilibrium market shares.

Our study supports the thought that the efficiency defense argument and the easy of entry argument can work in opposite directions. As suggested by the U.S. and EC Merger Guidelines, this study emphasizes the necessity and desire to investigate the postmerger impact on entry and exit.

We are aware that the impact of mergers on market structure depends on industry-specific institutional characteristics and is therefore an empirical question. We do not claim that our findings can be generalized easily to different industries. However, our study provides several arguments that apply beyond the semiconductor industry and can be applied to different industries. First, it emphasizes the relevance of considering the "ease of entry" argument and evaluating the associated postmerger impact on market structure. Our study also highlights the fact that mergers not only withdraw the merged firm from the product market, but can also cause exit. Finally, mergers can foreclose potential entry into other product markets. This argument carries over to many other markets where firms have a multimarket presence, such as most electronic product markets, but also pharmaceuticals, automobiles, and financial services, among many others.

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6 Appendix: Theoretical Motivation

As mentioned earlier, the reduced-form specification of our empirical model can be derived from a firm's supply relation in a standard Cournot oligopoly model with quite general demand and cost functions. Following Farrell and Shapiro (1990), we assume a Cournot oligopoly with homogeneous products. Inverse demand is given by $P(Q)$, where P is price, Q is industry output, and the slope of the inverse demand is negative, $P'(Q) < 0$. Firms, denoted by $i = 1, ..., N$, are allowed to differ in their efficiency levels where c_i refers to firm i's constant unit costs or marginal costs. In Cournot equilibrium, each firm chooses its output given its rivals' output where Q_{-i} refers to the aggregate output of all firms except firm i. Firm i's profits are

$$\pi_i = (P(Q) - c_i)q_i.$$

Firm i's first-order condition is

$$\frac{\partial \pi_i}{\partial q_i} = P(Q) + P'q_i - c_i = 0. \tag{3}$$

A Cournot equilibrium consists of a vector $(q_1, ..., q_N)$ such that equation (3) holds for all firms.[26] In equilibrium, more efficient firms produce more output. Adding up equation (3) across all N firms gives,

$$NP + P'Q - \sum_i c_i = 0$$

and solving for N gives,

$$N = \frac{\sum_i c_i - P'Q_{-i} - P'q_i}{P}. \tag{4}$$

Equation (4) shows that the number of firms (N) is, *ceteris paribus*, positively related to firms' marginal costs, demand or firms' overall output and the slope of demand. Since the number of firms present in the market is our study's main interest, equation (4) is useful to specify our empirical model. It is worth emphasizing the following aspects. First, since equation (4) suggests the inclusion of additional firm-level information (c_i and q_i), those unit of observations are defined at the firm-level in quarters. Moreover, since we focus on the DRAM industry, we can disregard the slope of the inverse demand as suggested by P' in equation (4). Finally, it should be noted that the price on the right hand side of equation (4) enters the denominator. Therefore, price causes a monotone transformation of the function that explains the number of firms, we will not have to include price as a regressor.

[26] As standard in Cournot, we assume that reaction curves, i.e., marginal revenues slope downward, $P'(Q) + q_i P''(Q) < 0, i = 1, ..., n$, where P'' is the second derivative of the inverse demand function with respect to industry output. Moreover, each firm's residual demand curve intersects its marginal cost curve from above, which is met if marginal costs are nondecreasing in firm-level output, i.e., $c_i'(q_i) \geq 0$.

7 Appendix: Tables

Table 1: Summary Statistics for the DRAM Market

Year	Q^D	N^D	HHI^D	$Entry^D$	$Exit^D$	$Merger^D$	$MPMerger^D$	$Merger^F$
1985	704,261	21	1,038	2	2	1	0	0
1986	923,190	20	1,208	2	4	0	0	0
1987	947,261	17	1,009	1	4	0	0	0
1988	1,268,150	20	866	3	0	0	0	0
1989	1,232,692	19	788	0	1	0	0	0
1990	1,323,370	19	814	0	0	0	0	0
1991	1,283,608	19	776	0	0	0	0	0
1992	1,472,201	19	751	0	0	0	0	0
1993	1,609,331	19	712	1	1	0	0	0
1994	1,805,310	18	763	0	1	0	0	0
1995	2,550,939	20	670	2	1	0	0	0
1996	2,663,570	23	709	5	0	0	0	0
1997	3,427,470	22	666	0	2	1	0	0
1998	3,724,846	21	870	1	2	2	1	1
1999	3,553,909	20	1,184	2	3	2	1	1
2000	3,390,879	15	1,639	1	6	1	1	1
2001	3,845,525	16	1,688	1	0	1	1	0
2002	4,156,450	18	1,433	4	2	0	0	0
2003	4,666,027	18	1,447	0	0	0	0	3
2004	5,379,103	19	1,512	2	3	0	0	0
Average	2,496,405	19	.	.	.	.	.	
Sum	.	.	.	27	32	8	4	6

Table 1 shows the summary statistics for the DRAM market. Production units for the industry output Q^D are reported in thousands. Sources: Thomson Financial and Gartner, Inc.

Table 2: Firms' Presence in the DRAM and Flash Markets

All Firms	DRAM	Flash	All Firms	DRAM	Flash
AT&T	1		Motorola	1	
AMD	1	1	M-Systems		1
Alliance Semic.	1	1	Nan Ya	1	
AMC Techn.		1	National Semic.	1	
American Microsyst.	1		NEC	1	1
Atmel		1	Nippon	1	
Catalyst		1	OKI	1	
Elite	1	1	PowerChip	1	
Elpida	1		Ramtron	1	
Etron	1		Renesas		1
Eurotech	1		Rohm		1
Fairchild	1	1	Samsung	1	1
Fujitsu	1	1	Sandisk		1
G-Link	1		Sanyo	1	1
Hitachi	1	1	Seiko	1	
Hynix	1	1	SGS-Thomson	1	1
Hyundai	1	1	Sharp	1	1
IBM Micro	1		Siemens	1	
Inmos	1		Signet	1	
Integrated Silicon	1		Silicon Techn.		1
Intel	1	1	Spansion		1
Intersil	1		ST Micro		1
LG Corp	1		STC	1	
Macronix		1	Sun Plus		1
Matsushita	1	1	Texas Instruments	1	1
Micron	1	1	TM Tech	1	
Mitsubishi	1	1	Toshiba	1	1
Mosel Vitelic	1		Vanguard	1	
Mostek	1		Winbond	1	1
			Zilog	1	

Table 2 shows the firms that produced in the DRAM and Flash markets between 1985 and 2004. Source: Gartner, Inc.

Table 3: Firms' Presence in the DRAM and Flash Markets

Time Period	MS^D of Merging Firms	MS^D of Nonmerging Firms	$Patents^D$ of Merging Firms	$Patents^D$ of Nonmerging Firms
$t^* - 4$	0.047	0.040	18.846	13.806
t^*	0.049	0.041	15.000	13.809
$t^* + 1$	0.056	0.042	15.077	13.338
$t^* + 4$	0.051	0.051	11.200	12.165
$t^* + 8$	0.060	0.058	9.200	10.161

Table 3 shows the DRAM market shares (MS^D) and DRAM patents ($Patents^D$) of merging and nonmerging firms. Note that t* refers to the time period when firms merged, and periods are counted in quarters. Sources: Thomson Financial, Gartner, Inc. and the U.S. Patent and Trademark Office.

Table 4: Impact of Mergers on Number of Firms

Dep. Variable: Number of firms	N_t^D	N_{t+4}^D	N_{t+8}^D
Independent Variables	(1)	(2)	(3)
$PS_{i,t-1}^D$	0.06E-03	-0.002*	0.312E-03
	(0.853E-03)	(0.001)	(0.125E-02)
$ACCQ_{i,t-1}^D$	-1.80E-06***	-1.51E-06***	-1.42E-06***
	(4.089E-08)	(4.88E-08)	(5.601E-08)
$Q_{-i,t-1}^D$	0.67E-04***	0.58E-04***	0.56E-04***
	(1.484E-06)	(1.773E-06)	(1.848E-06)
$q_{i,t-1}^D$	-2.18E-06	-2.91E-06	-3.620E-06
	(3.366E-06)	(4.021E-06)	(5.798E-06)
HHI_{t-1}^D	0.015***	0.013***	0.015***
	(3.32E-04)	(3.96E-04)	(0.406E-03)
$Merger_{t-1}^D$	-2.722***	-2.834***	-5.978***
	(0.339)	(0.4064)	(0.485)
$MPMerger_{t-1}^D$	1.159***	2.579***	1.444***
	(0.316)	(0.378)	(0.397)
$Merger_{t-1}^F$	-0.766**	-1.936***	-4.330***
	(0.422)	(0.504)	(0.524)
Adj. R-squared	0.528	0.955	0.316
Observations	1,447	1,329	1,226

Table 4 reports the estimation results for the impact of mergers on the number of firms, as shown in equation (3). Production units for the industry output Q^D, q_i^D and HHI^D are measured in thousands. The regression is estimated using 2SLS. The following instruments are used: Producer Price Index, wages, material price for silicon, GDP in electronics, the lagged endogenous regressors $q_{i,t-2}^D$, $Q_{-i,t-2}^D$, HHI_{t-2}^D and past accumulated firm-level output. Robust standard errors are reported in parentheses. ***, ** and * refers to a 1%, 5%, and 10% significance level, respectively. Sources: Thomson Financial, Gartner, Inc. and the U.S. Patent and Trademark Office.

Table 5: Impact of Mergers on Number of Firms

Dep. Variable: Number of firms	N_t^D	N_{t+4}^D	N_{t+8}^D
Independent Variables	(1)	(2)	(3)
$PS_{i,t-1}^D$	-0.0004	-0.0011	0.0003
	(0.609E-03)	(0.724E-03)	(0.904E-03)
$ACCQ_{i,t-1}^D$	-1.830E-06***	-1.530E-06***	-1.45E-06***
	(2.359E-08)	(2.815E-08)	(3.33E-08)
$Q_{-i,t-1}^D$	0.680E-04***	0.590E-04***	0.57E-04***
	(8.578E-07)	(1.02E-06)	(1.098E-06)
HHI_{t-1}^D	0.014***	0.0133***	0.0154***
	(0.201E-03)	(0.240)	(0.252E-03)
$Merger_{t-1}^D$	-2.982***	-3.032***	-6.017***
	(0.199)	(0.237)	(0.301)
$MPMerger_{t-1}^D$	1.031***	2.416***	1.203***
	(0.187)	(0.223)	(0.242)
$Merger_{t-1}^F$	-0.763***	-1.834***	-3.702***
	(0.239)	(0.286)	(0.302)
Adj. R-squared	0.317	0.842	0.334
Observations	1,447	1,329	1,226

Table 5 reports the estimation results for the impact of mergers on the number of firms, as shown in equation (3). Production units for the industry output Q^D, q_i^D and HHI^D are measured in thousands. The regression is estimated using 2SLS. The instruments are: Producer Price Index, wages, material price for silicon, GDP in electronics, the lagged endogenous regressors $q_{i,t-2}^D$, $Q_{-i,t-2}^D$, HHI_{t-2}^D and past accumulated firm-level output. Robust standard errors are reported in parentheses. ***, ** and * refers to a 1%, 5%, and 10% significance level, respectively. Sources: Thomson Financial, Gartner, Inc. and the U.S. Patent and Trademark Office.

Table 6: Impact of Mergers on Number of Firms

Dep. Variable: Number of firms	N_t^D	N_{t+4}^D	N_{t+8}^D
Independent Variables	(1)	(2)	(3)
$PS_{i,t-1}^D$	-1.53E-04	-2.016E-04**	1.287E-04
	(0.97E-04)	(0.986E-04)	(1.537E-04)
$ACCQ_{i,t-1}^D$	-2.16E-07***	-2.10E-07***	-2.15E-07***
	(4.62E-09)	(4.13E-09)	(4.50E-09)
$q_{i,t-1}^D$	-4.80E-07	-3.83E-07	-9.99E-07
	(4.11E-07)	(3.70E-07)	(6.33E-07)
$Q_{-i,t-1}^D$	7.64E-06***	7.59E-06***	7.77E-06***
	(1.52E-07)	(1.24E-07)	(1.25E-07)
HHI_{t-1}^D	0.002***	0.002***	0.0028***
	(0.246E-04)	(0.361E-04)	(0.377E-04)
$Merger_{t-1}^D$	-0.135***	-0.198***	-0.246***
	(0.031)	(0.035)	(0.030)
$MPMerger_{t-1}^D$	0.524***	0.495***	0.501***
	(0.027)	(0.028)	(0.051)
$Merger_{t-1}^F$	-0.31***	-0.41***	-0.395***
	(0.039)	(0.031)	(0.045)
GMM crit.	0.412	0.515	0.520
Observations	1,447	1,329	1,226

Table 6 reports the estimation results for the impact of mergers on the number of firms, as shown in equation (3). Production units for the industry output Q^D, $ACCQ^D$ and q_i^D are measured in thousands. The regression is estimated using instrumental variable Poisson methods, estimated by GMM. Instruments: Producer Price Index, wages, material price for silicon, GDP in electronics, the lagged endogenous regressors $q_{i,t-2}^D$, $Q_{-i,t-2}^D$, HHI_{t-2}^D and past accumulated firm-level output. Robust standard errors are reported in parentheses. ***, ** and * refers to a 1%, 5%, and 10% significance level, respectively. Sources: Thomson Financial, Gartner, Inc. and the U.S. Patent and Trademark Office.

Table 7: Impact on Price

Dep. Variable: Price	$log(P_t^D)$	$log(P_t^D)$
Independent Variables	(1)	(2)
$log(Q_t^D)$	-0.478***	
	(0.0626)	
$log(Q_{t-1}^D)$		-0.462***
		(0.073)
NOF_t^D	-0.0478**	-0.05**
	(0.022)	(0.025)
$GDPEL_t$	0.085***	0.079**
	(0.015)	(0.018)
$Merger_{t-1}^D$	0.116	0.101
	(0.128)	(0.155)
Adj. R-squared	0.524	0.292
Observations	80	79

Table 7, Column 1, reports the estimation results for the impact of mergers on prices, as shown in equation (4). Column 2 reports the results using lagged industry output as a regressor. Instruments are mentioned in the text. Robust standard errors are reported in parentheses. ***, ** and * refers to a 1%, 5%, and 10% significance level, respectively. Sources: Thomson Financial, Gartner, Inc. and the U.S. Patent and Trademark Office.

8 Appendix: Figures

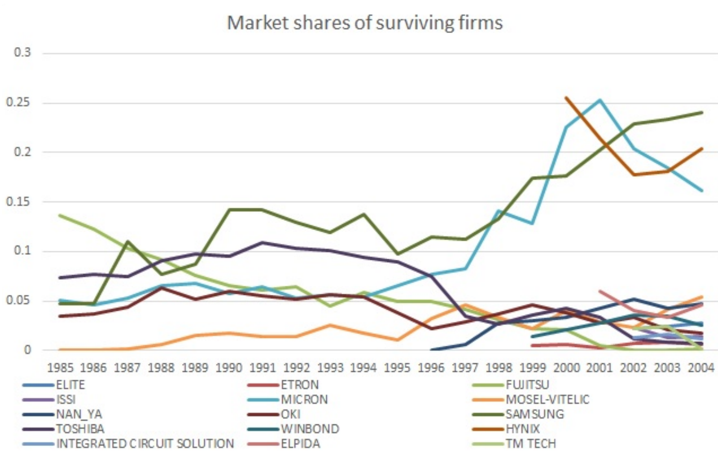

Figure 1: DRAM market shares of surviving firms across time

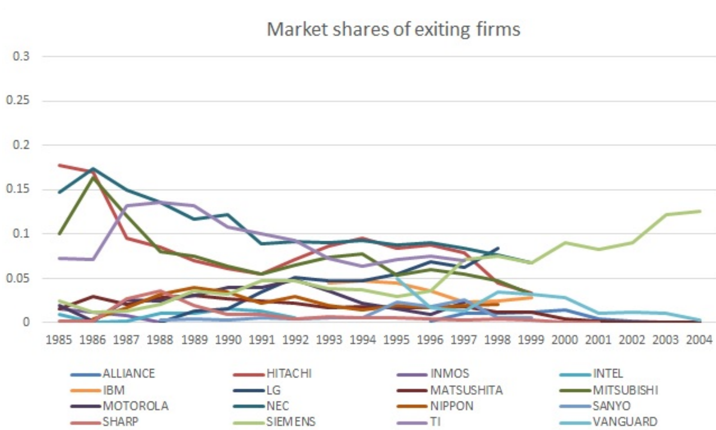

Figure 2: DRAM market shares of exiting firms across time

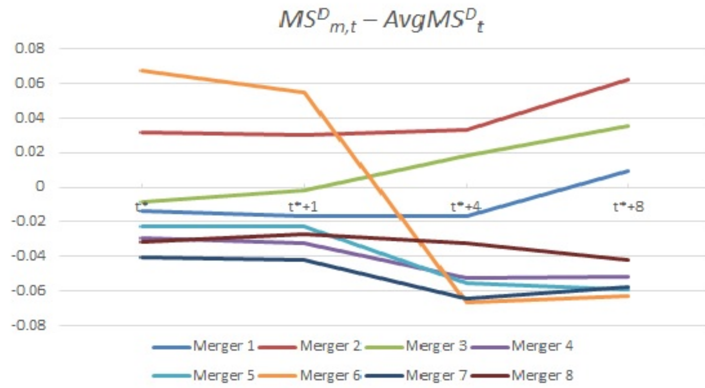

Figure 3: Changes in postmerger DRAM market shares across time and firms

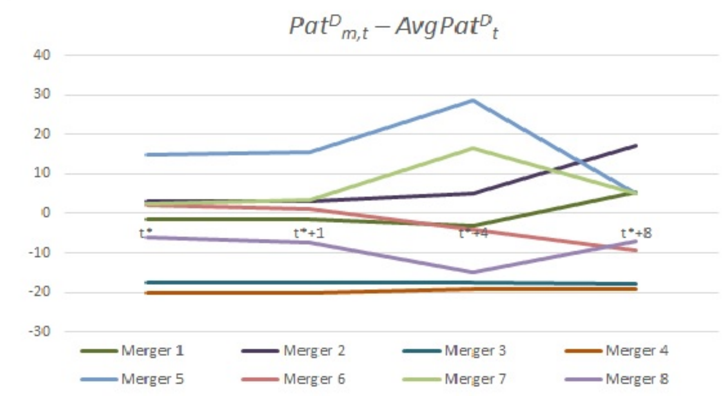

Figure 4: Changes in postmerger DRAM patents across time and firms