Market Power versus Efficiency Effects of Mergers and Research Joint Ventures: Evidence from the Semiconductor Industry

Klaus Gugler
Department of Economics
University of Vienna
Brünner Straße 72
1210 Vienna, Austria

Ralph Siebert
Department of Economics
Harvard University
Cambridge, MA 02138

Abstract

Merger control authorities may approve a merger based on a so-called "efficiency defence". An important aspect in clearing mergers is that the efficiencies need to be *merger-specific*. Joint ventures, and in particular research joint ventures (RJVs), may achieve comparable efficiencies possibly without the anti-competitive (market power) effects of mergers. We present evidence for the semiconductor industry that RJVs indeed represent viable alternatives to mergers. We empirically account for the endogenous formation of mergers and RJVs.

JEL: L13, L49, L63.

Keywords: Efficiency, Market Power, Mergers, Research Joint Ventures, Endogenous Switching, Semiconductor Industry.

Acknowledgments: We would like to thank Lars-Hendrik Roeller and Dennis C. Mueller for helpful comments and suggestions. We also thank Andrea Gaunersdorfer. We are very grateful to the "VolkswagenStiftung" and the OeNB Jubilaeumsfond project No. 8861 for financial support. We would also like to thank Harvard University for the hospitality, while working on this study. All remaining errors are our own.

Market Power versus Efficiency Effects of Mergers and Research Joint Ventures: Evidence from the Semiconductor Industry

Abstract

Merger control authorities may approve a merger based on a so-called "efficiency defence". An important aspect in clearing mergers is that the efficiencies need to be *merger-specific*. Joint ventures, and in particular research joint ventures (RJVs), may achieve comparable efficiencies possibly without the anti-competitive (market power) effects of mergers. We present evidence for the semiconductor industry that RJVs indeed represent viable alternatives to mergers. We empirically account for the endogenous formation of mergers and RJVs.

JEL: L13, L49, L63.

Keywords: Efficiency, Market Power, Mergers, Research Joint Ventures, Endogenous Switching, Semiconductor Industry.

1 Introduction

Many economists argue that competition authorities should take efficiency gains into account when examining merger cases. For example, Williamson (1968) highlighted the trade off between market power and efficiency effects. The US Department of Justice and Federal Trade Commission *Horizontal Merger Guidelines'* revisions (1992 and 1997) clarify the approval of mergers based on the "efficiency defence". If firms can convince merger control authorities that the efficiencies generated by the merger more than outweigh the market power effects (and these are passed-on to consumers), the merger may be cleared. Under these circumstances, price may decrease and consumer welfare may increase. However, a further aspect in clearing mergers is that the efficiencies need to be *merger-specific*. That is, that the efficiencies are "unlikely to be accomplished in the absence of either the proposed merger or another means having comparable anticompetitive effects." The Guidelines explicitly mention joint ventures that may achieve comparable efficiencies possibly without the anti-competitive effects of mergers. However, very little is known about the extent to which the different types of cooperations achieve efficiency and/or market power effects. This study provides insights to what extent mergers generate efficiency effects. Moreover, we examine whether the efficiency effects of mergers could possibly be achieved by viable alternatives, such as research joint ventures (RJVs). We analyze the efficiency versus market power effects for mergers and RJVs in the semiconductor industry during the period 1989 to 1999.

It is hard to compare pre and post merger allocations directly, even in the simplest oligopoly models. In a Cournot model with homogenous products, Farrell and Shapiro (1990) analyze how large the efficiency effects must be for a merger to lower price. They implicitly derive the cost efficiencies, which are necessary, from the change of merging firms' market shares. Therefore, the net effect of the efficiency and market power effect can be implicitly infered from the change in market shares post merger. Most commonly used models of oligopoly predict that if the market power effect of the combined firm outweighs any efficiency gains due to the merger, the market share of the merged firm drops relative to the sum of the market shares of acquiring and target firm before the merger, and market price increases. In contrast, if a merger generates sufficient cost synergies to outweigh the market power effect, the merging firms' market share will increase, inducing price to decline and consumer welfare to increase. Our theoretical model follows the framework of Farrell and Shapiro (1990), however, we allow for Cournot competition with differentiated products and compare mergers to RJVs.[1] We can confirm the basic results of Farrell and Shapiro (1990) for mergers and RJVs in an industry with differentiated products.

The empirical analysis builds on using firm-level market share data instead of using price and cost data. The advantage with using market shares is that they are easier to observe and more reliable than cost data. In order to correctly quantify the net effects of mergers and RJVs, we need to account for the endogeneity of the merger/RJV formation decision. By estimating an endogenous switching model, we can evaluate the net effects of mergers and RJVs under the different regimes.

Mergers and RJVs can achieve a number of remedies to the shortcomings of the innovation process.[2] Most notably, participating firms can internalize the positive externalities of R&D through coordinating their R&D investments. Other motives are e.g. avoiding wasteful duplication through information sharing, exploiting scale and scope effects in R&D, sharing risks associated with uncertain technologies as well as sharing large sunk set-up costs.[3] This may increase R&D investment and hence improve efficiency, which causes market shares to increase and prices to decrease (efficiency effect). Not surprisingly then, the theoretical as well as the empirical literature on RJVs conclude that RJVs

[1]There are several studies investigating differentiated products and price competition, see e.g. Deneckere and Davidson (1985), and Werden and Froeb (1994). We are not aware of any study investigating differentiated products with quantity setting firms, even though many industries, e.g. the semiconductor industry, can best be characterized by this form of competition. See Gowrisankaran (1999) and Dockner and Gaunersdorfer (2001) for analysis of mergers in a dynamic setup.

[2]A priori, one would expect that most efficiency effects can be attributed to RJVs. Indeed, antitrust treatment is more strict in the case of production joint ventures than in the case of RJVs, see the discussion in Jorde and Teece (1990) and Shapiro and Willig (1990).

[3]See further Katz and Ordover (1990), and Jacquemin (1988).

can be seen as an instrument to achieve efficiency gains and are beneficial to consumer welfare.[4] Moreover, RJVs - in contrast to full mergers - do not reduce the number of firms in the industry. Thus, the danger for market power increases appears to be much less for RJVs than for mergers. Competition authorities are well aware of this fact and view RJVs with benevolence. For example, the US Department of Justice enacted the *National Cooperative Research Act of 1984* in order to enforce RJVs. This act protects registered RJVs under the antitrust laws, such that they cannot be considered per se illegal, and must be judged by the antitrust rule of reason. Moreover, the act reduces the damage penalty in case of a violation of the antitrust laws.[5]

The crucial difference between mergers and RJVs consists in the behavior of firms in the product market. Whereas in RJVs firms make their production decisions independently, by definition firms act cooperatively in mergers.[6] A merger enables insiders to internalize the competitive externality in the product market and insiders reduce their production inducing market price to increase (market power effect).

Empirical evidence on the effects of mergers or RJVs on cost efficiencies or market shares is rather scant.[7] Up to date, there are only three studies that empirically analyze the effects of mergers on market shares. Goldberg (1973) finds no significant change in

[4] Widely cited theoretical contributions are Brander and Spence (1983), Spence (1984), Katz (1986), d'Aspremont and Jacquemin (1988) and Kamien, Muller and Zang (1992). See DeBondt (1996) for a survey on the literature on spillovers and innovative activity. Empirical studies predominantly analyzed the determinants of RJV formation, as well as their impact on R&D investment, and profitability. For the determinants of RJVs see Cassiman and Veugelers (1999), Röller, Siebert and Tombak (2000) or Kaiser (2002) among others, and for the effects on R&D spending or patenting activity, see Irwin and Klenow (1996) and Branstetter and Sakakibara (2002) among others.

[5] In the European Union, treatment of RJVs is also generally favorable. Under certain restrictions, there is a block exemption for R&D cooperation if the combined market shares of the cooperating firms are no greater than 25%. Even if a proposed R&D cooperation does not fall under the block exemption, it may nonetheless be permitted under Article 81(3) of the EU Treaty. There are also a number of government sponsored R&D projects worldwide, e.g. Sematech (Semiconductor Manufacturing Technology) in the USA, VLSI (Very Large Scale Integrated Circuits) in Japan or the Fifth Framework Programme in the EU.

[6] Note, as RJV formation may increase the possiblility of collusion in the product market (see Martin, 1995), the empirical analysis provides some lower bound for efficiencies.

[7] For more empirical studies analyzing the effects of mergers on profitability or sales growth, see, among others, Mueller (1980), Ravenscraft and Scherer (1987) and Gugler et al. (2002).

market shares of 44 companies acquired in the 50ies and 60ies in the (median three and a half) years following the merger. Baldwin and Gorecki (1990) find significant declines in market shares for plants acquired in horizontal mergers. Mueller (1985), the most ambituous study of mergers and market share, uses FTC market share data for the 1,000 largest companies in 1950 and 1972. His results indicate that while control-group firms (selected on the basis of industry and size) retained 55% of their 1950 market share in 1972, firms undertaking horizontal mergers retained only 14% of their 1950 market share. None of these studies confirm an increase in insiders' market shares indicating that the efficiency effect dominates the market power effect. Since consumer welfare is harmed through increased prices, the question remains unanswered why those mergers have been approved by competition authorities. Furthermore, endogenous selection might be an important aspect to account for in merger studies. We are not aware of any study analyzing the effects of RJVs on market shares.

In order to test for the effects of mergers and RJVs on market share, we focus on one of the most important high-technology industries, the semiconductor industry. This industry is characterized by a high degree of process and product innovation. For example, the patenting per million real R&D dollars of semiconductor firms doubled from 1982 to 1992, whereas e.g. in computing and electronics there was only a slight increase (see Hall and Ziedonis, 2001). The worldwide total revenues of the semiconductor industry reached 168.9 Billion USD in 1999, compared to 52.7 Billion USD in 1989. We construct a firm-level dataset covering *all* firms in the industry that operated in *any* year for the 11 year period 1989 to 1999. In total, 263 firms existed for at least one year during this period. We find that mergers indeed raise the market share of participating firms as do RJVs, providing evidence that efficiency effects dominate any market power effects for both forms of cooperation. However, we also find that the efficiency gains caused by mergers may have been achieved by RJVs as well. Therefore, RJVs often represent viable alternatives to mergers from the consumer welfare point of view.

The paper is structured as follows. Section 2 details the theoretical underpinnings for our empirical analysis. In Section 3, we describe our dataset on the semiconductor industry. In section 4, we perform the empirical analysis. We conclude in Section 5.

2 The Model

We consider N firms, each producing a single good. The goods are differentiated and the inverse demand function for firm i is

$$P_i = a - bq_i - g \sum_{j=1 j \neq i}^{N} q_j, \quad i = 1, \ldots, N$$

where P_i denotes the price of firm i, and q_i the quantity it produces. The demand intercept is given by a, and $b > 0$ represents the slope of the demand function. The substitutability parameter is g with $0 \leq g \leq b$. When $g = 0$ goods are totally differentiated and become closer substitutes the larger g, when $g = b$ products are perfect substitutes. We assume that initially each firm operates with the same constant-unit-cost technology such that total cost for firm i is given by $C(q_i) = cq_i$. We allow production being profitable, hence $a > c$, and no entry or exit occurs.

We consider two different types of coalitions. (1) Research Joint Ventures, where firms cooperate in R&D but not in the product market, and (2) mergers, where firms combine their assets and cooperate in the R&D and the product market. In every type there are two groups of firms, the insiders $M \leq N$, which participate in the coalition and the $N-M$ outsiders. Through efficiency gains the insiders (I) may achieve lower ex post marginal costs than the outsiders (O), $c^I < c^O$.

We assume that cooperations occur only when they are profitable. Thus, we do not endogenize the coalition process and do not investigate the effect on insiders' profits. In the product market, firms simultaneously choose their quantities. Firms choose their quantities noncooperatively, except in mergers where insiders make their quantity choice cooperatively.

In what follows, we analyze the change in equilibrium quantities of insiders and outsiders due to the formation of RJVs and mergers. Based on the change in equilibrium quantities we are able to infer the resulting cost efficiencies.

2.1 Merger and RJV

We assume that M out of N firms form either a merger (m) or an RJV (R). In both scenarios, insiders coordinate their R&D decisions to maximize their combined profits. Only in case of a merger, insiders also coordinate their production decisions. The outsiders remain competitors in the R&D as well as in the product market. We begin by analyzing the maximization problem for the outsiders, which is identical under merger and RJV. Next, we present the objectives for insiders in a merger and RJV, respectively.

2.1.1 The Outsiders

The $N-M$ outsiders (noncooperatively) maximize own profits:

$$\max_{q_i^O} \pi_i^O = \max_{q_i^O} \left\{ \left[a - g \left(\sum_{j=1}^{M} q_j^I + \sum_{j=M+1 j\neq i}^{N} q_j^O \right) - b q_i^O \right] q_i^O - c^O q_i^O \right\} , \quad i = M{+}1, \ldots, N$$

where q_i^O and q_j^I, $j = 1, \ldots, M$, are the outputs of an outsider and insider firm, respectively.

Firm i's first order condition with respect to quantity is

$$\frac{\partial \pi_i^O}{\partial q_i^O} = a - g \left(\sum_{j=1}^{M} q_j^I + \sum_{j=M+1 j\neq i}^{N} q_j^O \right) - 2b q_i^O - c^O = 0. \tag{1}$$

As equation (1) shows, the higher the rivals' output, the lower the marginal profits. The negative externality caused by rivals' output is not taken into account in the maximization problem, since individual profits are maximized. Note, that a higher substitutability parameter g, indicating a higher degree of competition, enlarges the negative externalities the firms impose on each other.

In symmetric equilibrium, $q_i^O \equiv q^O$ and $q_j^I \equiv q^I$, the outsider firms' reaction function is

$$q^O = \frac{a - gMq^I - c^O}{2b + g\left(N - M - 1\right)}. \tag{2}$$

From (2), insiders' and outsiders' quantities are strategic substitutes. Outsider output decreases with increasing own marginal costs c^O and with increasing substitutability parameter g.

2.1.2 The Insiders in a Merger

Assuming symmetry among the M insiders in a merger (m), they maximize joint profits, given by (nm are the outsiders of the merger):

$$\max_{q^m} M\pi^m = \max_{q^m} \left\{ M \left\{ \left[a - g \left[\sum_{j=M+1}^{N} q_j^{nm} + (M-1)q^m \right] - bq^m \right] q^m - c^m q^m \right\} \right\}.$$

The first order condition for an insider firm is

$$\frac{\partial \pi^m}{\partial q^m} = a - g \left[2(M-1)q^m + \sum_{j=M+1}^{N} q_j^{nm} \right] - 2bq^m - c^m = 0. \tag{3}$$

As insiders maximize joint profits, they internalize the negative externality they impose on each other. Consequently, industry output declines and market prices increase, i.e. the market power effect.

Assuming symmetry among the $N-M$ outsiders, the merging firms' reaction function is

$$q^m = \frac{a - g\left(N - M\right)q^{nm} - c^m}{2\left[b + g\left(M - 1\right)\right]}. \tag{4}$$

Plugging equation (2) into (4), gives the equilibrium quantity for the merging firm

$$q^{*m} = \frac{a\left(2b - g\right) + g\left[\left(N - M\right)\left(c^{nm} - c^m\right)\right] - c^m\left(2b - g\right)}{2b\left[2b + g\left(N + M - 3\right)\right] + g^2\left[M\left(N - M\right) - 2\left(N - 1\right)\right]}.$$

Plugging q^{*m} into equation (2) gives the equilibrium quantities for the outsiders, q^{*nm}. Subtracting equation (1) from (3), imposing symmetry, and rearranging we get

$$\frac{2b + g\left(M - 2\right)}{2b - g} q^{*m} - q^{*nm} = \frac{c^{nm} - c^m}{2b - g} \tag{5}$$

Let us first suppose that the merger generates no efficiency gains ($c^m = c^{nm}$) such that only the market power effect is present. When products are perfect substitutes ($g = b$), $Mq^{*m} = q^{*nm}$, and we can confirm the results established by Salant, Switzer and Reynolds (1983), that the insiders reduce their production so much that symmetric Cournot symmetry is again established in the post-merger equilibrium. Of course, the more firms merge, the larger is the output reduction.[8] Outsiders respond by increasing their output, but by less (see equation (2)). Consequently, industry output declines and market price increases due to the market power effect.

As products become more differentiated (g declines), insider firms reduce their output by less, since $\frac{\partial\left(\frac{2b+g(M-2)}{2b-g}\right)}{\partial g} > 0$. The reason is that the negative externalities the insider firms impose on each other in the product market are lower due to a higher degree of product differentiation. Therefore, the extent to which insider firms gain market power is lower and insider firms reduce their output by less. It follows that the increase in industry price is smaller, when products are more differentiated. When products are totally differentiated ($g = 0$), insider and outsider firms do not change output, as $q^{*m} = q^{*nm}$. This is intuitive, since firms already behaved like monopolists before the merger and did not impose any externalities in the product market on each other. Hence, there is no further market power gain and the industry price remains the same. We can impose the following result in case the merger generates no efficiency gains: The more the products are differentiated, the less the insiders reduce their output and the less industry price increases post merger.

In case the merger creates efficiency gains ($c^m < c^{nm}$), and considering perfect substitutes ($g = b$), we get $Mq^{*m} = \frac{c^{nm}-c^m}{b} + q^{*nm}$. Therefore, the combined insiders' quantity is higher than the outsider quantity. Moreover, the more efficient insiders become relative to outsiders, the more insider production and industry output increase. If the efficiency gains due to the merger are sufficiently high, the output of a single insider may even exceed

[8]In our sample there is no merger where more than two firms merge.

an outsider's output ($q^{*m} > q^{*nm}$). In this case, the efficiency effect more than outweighs the market power effect, inducing prices to decline, and the post-merger industry price will be smaller than the pre-merger industry price.

When products become more differentiated (g declines), equation (5) again shows that for any given efficiency effect insiders decrease their output by less. We can impose the following result in case the merger generates efficiency gains: When the efficiency gains induced by the merger are sufficiently large a single insider firm produces a higher quantity than an outsider. In this case the efficiency effect dominates the market power effect and industry price declines compared to the pre-merger price. Moreover, the more the products are differentiated, the smaller are the efficiency gains needed to overcompensate the market power effect.

For our empirical analysis it is important to note that we have shown that the predictions of Farrell and Shapiro (1990) hold for any degree of product differentiation. Therefore, we can impose the following: If the market share of each insider increases (declines) compared to an outsider's market share due to a merger, the efficiency gains created by the merger dominate (are dominated by) the market power effects, and price will decline (increase).

2.1.3 The Insiders in an RJV

The M insiders forming an RJV (R) maximize their profits in the product market non-cooperatively, as shown by

$$\max_{q_i^R} \pi_i^R = \max_{q_i^R} \left\{ \left[a - g \left(\sum_{j=1 j\neq i}^{M} q_j^R + \sum_{j=M+1}^{N} q_j^{nR} \right) - b q_i^R \right] q_i^R - c^R q_i^R \right\}$$

where nR denote non-RJV firms (outsiders).

The first order condition for firm i is

$$\frac{\partial \pi_i^R}{\partial q_i^R} = a - g \left(\sum_{j=1 j\neq i}^{M} q_j^R + \sum_{j=M+1}^{N} q_j^{nR} \right) - 2b q_i^R - c^R = 0.$$

As profits are maximized noncooperatively, the negative output externality the insiders impose on each other is not taken into account. Therefore, the market power effect is not present. The efficiency effect, however, occurs when the RJV reduces marginal costs.

Again assuming symmetry among the outsiders, $q_j^{nR} \equiv q^{nR}$ $(j = M+1, \ldots, N)$, in symmetric equilibrium the RJV firms' reaction function is

$$q^R = \frac{a - g\,(N-M)\,q^{nR} - c^R}{2b + g\,(M-1)}. \tag{6}$$

Plugging equation (2) into equation (6) and solving for the corresponding equilibrium quantities for the RJV firms, gives

$$q^{*R} = \frac{a\,(2b-g) + g\left[(N-M)\left(c^{nR} - c^R\right) + c^R\right] - 2bc^R}{(2b-g)\,[2b + g\,(N-1)]}. \tag{7}$$

Plugging the equilibrium quantity q^{*R} into equation (2) gives the equilibrium quantity q^{*nR} for the RJV outsiders

$$q^{*nR} = \frac{a\,(2b-g) + g\left[c^{nR} - M\left(c^{nR} - c^R\right)\right] - 2bc^{nR}}{(2b-g)\,[2b + g\,(N-1)]}. \tag{8}$$

Taking the difference of equations (7) and (8), we get

$$q^{*R} - q^{*nR} = \frac{c^{nR} - c^R}{2b - g}. \tag{9}$$

Suppose again that there are no efficiency gains such that $c^R = c^{nR}$. Then $q^{*R} = q^{*nR}$ and insider firms produce as much as the outsiders, i.e. their output does not change due to the formation of an RJV (no market power effect). However, if the RJV creates efficiency gains $\left(c^R < c^{nR}\right)$, $q^{*R} > q^{*nR}$ and insiders raise output compared to outsiders. The higher the efficiency gains generated by the RJV, the more the insiders raise output compared to outsiders. The more differentiated products are (the lower g), the less output is increased by insiders for a given efficiency gain. As the optimal response by the outsiders is to lower their quantity by less than insiders increased their output, industry price will decline, once the RJV generates efficiency gains. Note that this argument holds under the assumption of no product market collusion. If RJV firms collude in the product market, an RJV behaves like a merger and the logic from above applies.

From equations (5) and (9), we are able to evaluate if the efficiency effect outweighs the market power effect in mergers and RJVs. If the market share of each insider increases compared to an outsider's market share, due to merger/RJV, the efficiency gains created by the merger/RJV overcompensate the (potential) market power effects, and price will necessarily decline.[9] This is consistent for any degree of product differentiation in the market. Moreover, we are able to implicitly derive the extent of cost savings induced by the merger/RJV from comparing the change in insiders' and outsiders' market shares. [10]

3 The Data

Firms' annual market shares in the semiconductor industry are provided by Gartner Group. This company collects data on production values for each firm operating in the semiconductor industry on an annual basis. Thus, we do not need to rely on accounting information to infer market shares. The data source for research joint ventures and mergers is the Thompson Financial Securities Database. This database includes alliances with a deal value of more than 1 Mio. USD ensuring that the overwhelming majority of mergers and research joint ventures is covered.

Table 1 presents summary statistics. Panel A displays statistics on market shares of all firms producing for at least one year in the semiconductor industry worldwide from 1989 to 1999, for yearly subperiods as well as for the whole period. The semiconductor industry can be characterized as a fairly unconcentrated industry with a mean (median)

[9] The likely consequences of allowing for entry and exit are the following: Market shares of insiders would increase by more if the efficiency effect dominates the market power effect, since some outsiders would exit. Market shares of insiders would decrease by more if the market power effect dominates the efficiency effect, since other firms may enter. Thus, the assumption of no entry and exit in our study makes the analysis even more conservative. See Werden and Froeb (1998) for an analysis of the entry-inducing effects of mergers.

[10] See also Röller and Stahl (2002) for the welfare effects of mergers and joint ventures.

market share of 0.64% (0.11%).[11] On average, 157 firms produce in the industry in a given year, 263 firms produce for at least one year.

Panel B presents statistics on the number of completed deals. There are 43 horizontal mergers and 67 RJVs (actually RJV years) during the 1989-1999 period. A research joint venture is defined to operate in the semiconductor industry if the main objective of the research refers to the Standard Industrial Classification (SIC) 3674. On average 2.92 firms participate in an RJV.[12]

Panel C presents summary statistics on firms participating in mergers and RJVs. With respect to mergers, acquiring firms have a mean (median) market share of 2.5% (0.5%) in the year before the merger, while their targets are considerably smaller (mean 0.3%, median 0.05%). Cumulative market shares taken over in the industry add up to 10.7%. The average (median) market share of RJV firms is 3.15% (2.32%).[13]

4 The Empirics

In order quantify the market power versus efficiency effects of mergers and RJVs, we compare the pre merger market shares of insiders with post merger market shares.[14] First, we estimate a dummy variable model. Later on, we correct for the endogeneity of merger/RJV formation and estimate an endogenous switching model. Hence, we estimate the following equation

$$sc_{i,t} = a_c + b \cdot sc_{i,t-x-1} + \sum_{y=0}^{x} m_y \cdot Merger_{i,t-y} + \sum_{y=0}^{x} r_y \cdot RJV_{i,t-y} + \epsilon_{i,t} \qquad (10)$$

[11] Accordingly, the average Herfindahl-Hirschmann index of market concntration is very low at 0.00027. The leading firm (INTEL CORP in all years) nearly doubled its market share from 8.5% in 1989 to 15.9% in 1999.

[12] This is consistent with the notion that the potential beneficial effects of RJVs increase with the number of participating firms, since technological spillovers increase (see Baumol, 2001).

[13] This fact is consistent with the notion by Irwin and Klenow (1996), that larger firms gain more from RJVs and from R&D knowledge spillovers.

[14] As we have shown in our theoretical part, the predictions concerning market shares apply for any degree of product differentiation, thus we can ignore the parameter for the market share estimation.

for $i = 1 \ldots 263$ and $t = 1989 \ldots 1999$. If there is no merger, $sc_{i,t}$ is simply the market share of firm i in period t. If there is a merger, $sc_{i,t}$ is the sum of the market shares of the acquiring and acquired company, i.e. the combined market share, before the merger, and the market share of the acquiring firm after merger. The parameters a_c are country/country group dummies for the USA, Europe, Japan and Korea. In order to test for market power and efficiency effects of mergers and RJVs, we investigate the change of insiders' and outsiders' market shares by using a dummy variable approach: we define $Merger_{i,t-y} = 1$, if firm i took over another firm in period $t - y$, and zero elsewise, or by analogy, $RJV_{i,t-y} = 1$, if firm i participated in a research joint venture in period $t-y$, and zero elsewise.[15] The inclusion of the lagged dependent variable $sc_{i,t-x-1}$ effectuates that the coefficients on the dummy variables measure changes in market shares. Equation (10) is estimated separately for the different lag parameters $x = 0, 1, 2, 3$. Thus, we determine the impact of mergers and RJVs up to three years after the deals. For example, the total effect of a merger on market share undertaken in period t three years later is $\sum_{y=0}^{3} m_y$. A positive sum of coefficients on the dummy variables indicate that the efficiency effect dominates the market power effect.

Unit root tests indicate that the stochastic market share data generating process is stationary. Dickey-Fuller as well as augmented Dickey-Fuller tests reject the null hypothesis that market share contains a unit root. The t-values for the coefficient of the lagged dependent variable in regressions of the first difference of market share on market share lagged by one period range from -5.45 (pooled OLS), -6.12 (OLS fixed effects) to -6.26 (IV method of Anderson and Hsiao, 1982).[16] Thus, these values are above the 1% critical values as e.g. tabulated by Fuller (1976). Since market shares are $I(0)$, least squares

[15]It should be noted, that there are only two firm years where there is both a merger and an RJV. Thus, multicollinearity among the merger and RJV dummies is no problem.

[16]The method of Anderson and Hsiao (1982) involves first differencing to account for unobserved firm level heterogeneity and then instrumenting $\Delta y_{i,t-1}$ by $\Delta y_{i,t-2}$ and/or $y_{i,t-2}$, which are valid instruments since they are correlated with $\Delta y_{i,t-1}$ but uncorrelated with $\Delta \mu_{it}$. The Anderson and Hsiao (1982) estimator is consistent when $N \longrightarrow \infty$ or $T \longrightarrow \infty$ or both.

provides $\sqrt{T}$ consistent estimates for the parameters of interest, however these estimators will be biased for small T. In particular, the coefficient on the lagged dependent variable will be biased downwards, towards zero. Therefore, we instrument $sc_{i,t-x-1}$ by the stock of patents in the semiconductor industry by firm i as of year $t-1-x$ and estimate by 2SLS.[17] The firm's patents stock appears to be a suitable instrument, since the simple correlation coefficient with market share is 0.61 ($p = 0.000$) and the correlation coefficient with the residuals of equations (10) is near zero.

4.1 Results

Table 2 reports the regression results of equation (10). As shown, mergers significantly increase the market share of the combined entity relative to pre-merger levels in the semiconductor industry. The cumulative effect of mergers on market shares is +1.0 percentage points ($t = 7.22$) three years after the merger ($x = 3$). The results also indicate that RJVs significantly increase market share of their participating firms. RJVs significantly affect market share in the second and third years after formation (see columns for $x = 3$). The cumulative effects of RJVs on market share of the participating firms is 0.52 percentage points with a t-value of 3.33. As 2.92 firms form an RJV on average, the cumulative increase in market share is 1.5 percentage points three years after the formation. While we cannot assure that RJVs do not lead to collusion in the product market, we can state that the efficiency effects of RJVs more than outweigh any potential anti-competitive effects. Our results imply that mergers and RJVs raise the market shares of participating firms. This points to an efficiency increasing role of mergers and RJVs. However, RJVs raise market shares of participants by 0.5 percentage points more, collectively.[18]

The country dummy variables (jointly significant beyond the 1% level) indicate that

[17]Source: NBER patents database of Hall et al. (2001).

[18]Moreover, from Table 2 and x = 3, mergers have a negative (albeit insignificant) effect in year three after the merger, while RJVs still positively and significantly influence market shares of insiders. This suggests that the beneficial effects of RJVs are longer-lasting than those of mergers. Unfortunately, our dataset does not sensibly allow us to go beyond year three after the deals.

Japanese semiconductor firms significantly lost market shares relative to all other countries depicted during the 90ies (they lost on average 0.14% per annum), while Korean semiconductor firms significantly improved their relative market position (on average they gained 0.13% per annum). US and European semiconductor firms were about equally successful in retaining their market share. This is consistent with popular opinion.

Equation (10) is robust to the following modifications. (1) Our dummy variable methodology treats each RJV-year symmetrically, however some firms form more than one joint venture in a given year.[19] If we include the number of RJVs formed in a given year as a count variable, the results are virtually identical to the ones obtained by introducing dummies, thus we report only the latter. (2) Results are also nearly identical if we estimate equation (10) by OLS instead of 2SLS or in first-difference form instead of including a lagged dependent variable. (3) Finally, the results are qualitatively identical if we include firm fixed effects and estimate the dynamic panel by the IV method of Anderson and Hsiao (1982). This method eliminates firm fixed effects by using first differences and then instrumenting by lagged differences and/or levels of the variables. RJVs and mergers continue to significantly increase the market shares of firms in the semiconductor industry.

4.2 Endogenous Switching

One criticism that mergers or RJV studies often face is the endogeneity of the merger/RJV formation. For example, it may happen that mergers or RJVs are formed among firms, which will - even without merger/RJV - gain market share in the future, say because one of the firms (e.g. the target) made a significant innovation in year $t-1$. A comparison with outsider firms may indicate increasing market shares due to the merger/RJV, which is in fact due to the innovation unrelated to the merger. If this innovation is the reason for the merger, the merger is said to be endogenously formed. In other words, the within firm

[19] We do not have that problem for mergers.

variation in merger or joint venture activity may be (partially) endogenously determined, and merger or RJV years are a self-selected sample of observations.

Our endogenous switching model imposes one selection equation for each regime, merger and RJV, respectively. The switching equations analyze to what extent the firms were able to retain their pre-merger (pre-RJV) market shares.[20] Thus, we estimate the following system:

$$I^*_{i,t} = b_0 + b_1(sc_{m,i,t} - sc_{nm,i,t}) + b_2 \cdot X_{i,t} - v_{i,t} \tag{11}$$

$$sc_{m,i,t} = a_{m,0} + a_{m,1} \cdot sc_{m,i,t-x-1} + \varepsilon_{m,i,t} \tag{12}$$

$$sc_{nm,i,t} = a_{nm,0} + a_{nm,1} \cdot sc_{nm,i,t-x-1} + \varepsilon_{nm,i,t} \tag{13}$$

Equation (11) is a selection equation that determines whether or not the firm takes over another firm in year t (forms an RJV). Note, that firm i's decision to merge/form an RJV depends on the comparison of the expected market shares when it cooperates (merges) versus when it does not cooperate (merge). Variable X is a set of exogenous variables determining merger/RJV formation, that is variables affecting the costs and benefits of the deals, such as country fixed effects or the number of patents a firm owns. Variables are defined as before, with the subscript m referring to merging observations and subscript nm referring to non-merging observations. Variables for the RJV estimations are determined by analogy.

If $I^*_{i,t} > 0$, the firm forms a merger (RJV), and the market share is determined by equation (12), otherwise its market share is determined by equation (13). There are two problems with estimating the set of equations. First, we have a missing data problem. We only observe the market share given the chosen regime, that is, we observe $sc_{m,i,t}$ if $I^*_{i,t} > 0$, or $sc_{nm,i,t}$ otherwise, but never both. Another problem is that OLS estimation of equations (12) and (13) gives inconsistent estimates, because $\mathrm{E}(\varepsilon_{m,i,t}|I^*_{i,t} > 0) \neq 0$ and

[20] This is essentially what also Mueller (1985) studied. The endogenous switching model is in line with Lee (1978).

$E(\varepsilon_{nm,i,t}|I^*_{i,t} \leq 0) \neq 0$. Thus, we substitute equations (12) and (13) into equation (11), and estimate the "reduced form" probit by ML. From this estimation, we retrieve the inverse Mills ratio and estimate equations (12) and (13) consistently with 2SLS.[21] Using these estimates to calculate the predicted difference in market shares for the two regimes, plugging those into the "structural" probit equation (11), and estimating the whole system by ML, one gets consistent estimates of the $a's$ and $b's$. The parameters of main interest are $a_{m,1}$ and $a_{nm,1}$, i.e. the percentage of market share retained of merging versus non-merging firms (RJV forming versus non-RJV forming firms) after x years, taking into account the endogenous nature of merger/RJV formation.

Table 3 presents the results for $x = 3$. The merger and RJV selection estimations from the "structural" probit equation show that merger/RJV formation indeed is significantly determined by the expected gains in market shares. Interestingly, while own patents negatively influence the decision to merge, they positively influence the decision to form an RJV.[22]

From the corrected market share regression, merging firms are able to expand their market share by 19% three years after a merger as compared to non-merging firms loosing nearly 14% during that period, on average. RJV participating firms are able to expand their market share by nearly 10% three years after the formation of an RJV as compared to non-RJV firms loosing more than 12% during that period, on average. These numbers are very much in line with the estimates from section 4.2 using a dummy variable technique and ignoring endogenous switching. In sum, while mergers and RJVs are to some extent endogenously determined, our main results are not altered by explicitly considering and

[21]We again use the accumulated number of patents in the semiconductor industry of firm i in year $t - x - 1$ as instrument for market shares.

[22]One interpretation would be that absorptive capacity plays an important role in the R&D process (see Cohen and Levinthal, 1989). In an RJV (the "make" decision) firms can capture spillovers from the other participating firms. The more patents one has the more likely it is to benefit from these spillovers. Thus complementary aspects of the innovation process may prevail. Mergers (the "buy" decision), on the other hand, is a much more binding form of cooperation and R&D capacity may actually be brougth "in house" to rectify own shortcomings. See Blonigen and Taylor (2000) for recent evidence on a negative relation between R&D and acquisition activity in high-tech industries.

correcting for this endogeneity.

5 Conclusion

Our study contributes to merger and RJV control policy. A merger may be approved based on a so-called *"efficiency defence"*: If firms can convince merger control authorities that the efficiencies generated by the merger more than outweigh the anti-competitive effects, the merger may be cleared. An important aspect in clearing mergers is that the efficiencies are *merger-specific*. That is, that the efficiencies cannot be achieved by any other means with comparable or lower anti-competitive effects, such as RJVs.

This study finds that mergers increase the market shares of participating firms. This points to an efficiency enhancing role of mergers. However, we also find that RJVs are indeed viable alternatives to mergers. Cumulatively, RJVs raise insiders' market shares by more than a merger and achieve higher efficiency gains and consumer welfare. This result is robust to endogenous merger or RJV formation. We conclude that efficiency gains are frequently not merger-specific, given the possibility of a research joint venture. In such circumstances the merger should not be cleared as RJVs achieve at least the same efficiency gains without the anticompetitive market power effects.

At least three important caveats must be mentioned, however. First, we find that RJVs are formed among larger firms. This is indicative for Schumpeterian effects in innovation in R&D intensive industries, and some RJVs may not be formed among smaller firms whereas a merger may happen. Second, we did not analyze other forms of joint ventures such as pure production joint ventures. It may be that these forms of cooperation increase collusion in the product market without offsetting efficiency advantages. Finally, our analysis is restricted to the semiconductor industry, one of the most R&D intensive and collaborative industries. The results presented in this study only apply for this industry. Future research is needed to confirm our main result - RJVs are often viable alternatives to mergers - for other industries, as to establish more insight for antitrust control authorities.

6 References

Anderson, T.W. and C. Hsiao, 1982, "Estimation of Dynamic Models with Error Components", Journal of the American Statistical Association 76, 598–606.

Baldwin, J. and P.A. Gorecki, 1990, "Mergers Placed in the Context of Firm Turnover", in Bureau of the Census, 1990 Annual Research Conference, Proceedings, Washington D.C.: U.S. Department of Commerce, 53–73.

Baumol, W.J., 2001, "When is inter-firm coordination beneficial? The case of innovation", International Journal of Industrial Organization 19, 727–737.

Blonigen, B.A. and C.T. Taylor, 2000, "R&D Intensity and Acquisition in High-Technology Industries: Evidence from the US Electronic and Electrical Equipment Industries, Journal of Industrial Economics, Vol. XLVIII, No. 1, 47–70.

Brander, J.A. and B. Spencer, 1983, "Strategic Commitment with R&D: the Symmetric Case", Bell Journal of Economics 14, 225–235.

Branstetter, L. G. and M. Sakakibara, 2002, "When Do Research Consortia Work Well and Why? Evidence from Japanese Panel Data", American Economic Review, Vol. 92, No. 1, 143–159.

Cassiman, B. and R. Veugelers, 1999, "R&D Cooperation and Spillovers: Some Empirical Evidence", CEPR discussion paper 2330.

Cohen, W.M. and D.A. Levinthal, 1989, "Innovation and Learning: The Two Faces of R&D", The Economic Journal 99, 569–596.

D'Aspremont, C. and A. Jacquemin, 1988, "Cooperative and Non-Cooperative R&D in Duopoly with Spillovers", The American Economic Review 78, 1133–1137.

DeBondt, R., 1997, "Spillovers and Innovative Activities", International Journal of Industrial Organization 15, 1–28.

Deneckere, R. and C. Davidson, 1985, "Incentives to Form Coalitions with Bertrand Competition," Rand Journal of Economics, 16, 473–486.

Dockner, E.J. and A. Gaunersdorfer, 2001, "On the Profitability of Horizontal ' Mergers in Industries with Dynamic Competition," Japan and the World Economy, 13, 195–216.

Farrell, J. and C. Shapiro, 1990, "Horizontal Merger: An Equilibrium Analysis", American Economic Review, Vol. 80, No. 1, 107–126.

Fuller, W.A., 1976, "Introduction to Statistical Time Series", J. Wiley & Sons, Inc., New York.

Goldberg, L., 1973, "The Effect of Conglomerate Mergers on Competition", Journal of Law and Economics, 16, 137–158.

Gowrisankaran, G., 1999, "A Dynamic Model of Endogenous Horizontal Mergers" RAND Journal of Economics, Spring, Vol. 30(1), 56-83.

Gugler, K., D.C. Mueller, B.B. Yurtoglu and C. Zulehner, 2002, "The Effects of Mergers: An International Comparison", forthcoming International Journal of Industrial Organization.

Hall, B.H., A.B. Jaffe and M. Trajtenberg, 2001, "The NBER Patent Citation Data File: Lessons, Insights and Methodological Tools" NBER Working Paper No. 8498.

Hall, B.H. and R.H. Ziedonis, 2001, "The Patents Paradox Revisited: An Empirical Study of Patenting in the U.S. Semiconductor Industry, 1979-1995, Rand Journal of Economics, 32, 101–128.

Irwin, D.A. and P.J. Klenow, 1996, "High-tech R&D Subsidies: Estimating the Effects of Sematech", Journal of International Economics 40, 323–344.

Jacquemin, A., 1988, "Cooperative Agreements in R&D and European Antitrust Policy", European Economic Review 32, 551–569.

Jorde, T.M. and D.J. Teece, 1990, "Innovation and Cooperation: Implications for Antitrust", Journal of Economic Perspectives 4, 75–96.

Kaiser, U., 2002, "An empirical test of models explaining research expenditures and research cooperation : evidence for the German Service sector", International Journal of Industrial Organization 20, 747–774.

Kamien, M.I., E. Muller and I. Zang, 1992, "Research Joint Ventures and R&D Cartels", American Economic Review 82, 1293–1306.

Katz, M., 1986, "An Analysis of Cooperative Research and Development", Rand Journal of Economics 17, 527–543.

Katz, M. and J. Ordover, 1990, "R&D Cooperation and Competition", Brookings Papers on Economic Activity, Microeconomics, 137–191.

Lee, L.F., 1978, "Unionism and Wage Rates: A Simultaneous Equations Model with Qualitative and Limited Dependent Variables", International Economic Review, 19, No. 2, 415–433.

Martin, S., 1995, "R&D Joint Ventures and Tacit Product Market Collusion", European Journal of Political Economy 11, 733–741.

Mueller D.C., ed., "The Determinants and Effects of Mergers: An International Comparison", Cambridge, Mass.: Oelgeschlager, Gunn & Hain, 1980.

Mueller, D.C., 1985, “Mergers and Market Share”, Review of Economics and Statistics, 67(2), 259–267.

Ravenscraft, D.J. and F.M. Scherer, 1987, “Mergers, Sell-Offs and Economic Efficiency”, The Brookings Institution, Washington, D.C.

Röller, L.H., R. Siebert and M.M. Tombak, 2000, “Strategic Choice of Partners: Research Joint Ventures and Market Power”, Wissenschaftszentrum Berlin.

Röller, L.H. and K. Stahl, 2002, “Merger vs. Research Joint Venture under R&D Efficiencies”, Wissenschaftszentrum Berlin and University of Mannheim.

Salant, S.W., S. Switzer and R.J. Reynolds, 1983, “Losses from Horizontal Merger: The Effects of an Exogenous Change in Industry Structure on Cournot-Nash Equilibrium”, Quarterly Journal of Economics, Vol. XCVIII, No. 2, 185–199.

Shapiro, C. and R.D. Willig, 1990, “On the Antitrust Treatment of Production Joint Ventures”, Journal of Economic Perspectives 4 (3), 113–130.

Spence, M., 1984, “Cost Reduction, Competition and Industry Performance”, Econometrica 52 (1), 101–121.

Werden, G.J., and L.M. Froeb, 1994, “The Effects of Mergers in Differentiated Products Industries: Logit Demand and Merger Policy”, Journal of Law, Economics, and Organization, 10 (2), 407–426.

Werden, G.J., and L.M. Froeb, 1998, “The Entry-Inducing Effects of Horizontal Mergers: An Exploratory Analysis”, Journal of Industrial Economics, 46 (4), 525–543.

Williamson, O.E., 1968, “Economies as an Antitrust Defense: The Welfare Tradeoffs”, American Economic Review, 58, 18–36.

Table 1a: Market shares in the semiconductor industry

Years	Mean	Median	No. Firms
1989	0.77%	0.15%	130
1990	0.72%	0.15%	138
1991	0.77%	0.16%	130
1992	0.65%	0.13%	155
1993	0.66%	0.12%	151
1994	0.66%	0.10%	152
1995	0.57%	0.08%	170
1996	0.64%	0.10%	156
1997	0.56%	0.10%	170
1998	0.54%	0.09%	186
1999	0.61%	0.12%	165
Average	0.64%		157
Total			263

Table 1b: : Research joint ventures and mergers: number of deals

Years	RJVs	Mergers
1989	3	1
1990	5	5
1991	8	2
1992	4	2
1993	7	2
1994	12	2
1995	10	7
1996	7	4
1997	5	4
1998	2	9
1999	2	5
1989-1999	67	43

Table 1c: Market shares of different groups of firms in $t-1$

	Mean	Median	S.D.	Minimum	Maximum
RJV firms	3.15	2.32	2.91	0.02	13.79
Mergers					
Acquiring firms	2.46	0.47	4.10	0.01	16.47
Target firms	0.30	0.05	0.58	0.00	2.02

Table 2: Results for equation (10)

Dependent variable: $sc_{i,t}$								
Equation	1		2		3		4	
	$x = 0$		$x = 1$		$x = 2$		$x = 3$	
	Coef	t-value	Coef	t-value	Coef	t-value	Coef	t-value
USA	0.00013	0.92	0.00027	1.06	0.00046	1.27	0.00068	1.27
Europe	0.00007	0.29	0.00007	0.06	−0.00003	−0.03	−0.00003	−0.03
Japan	−0.00138	−6.24	−0.00302	−7.75	−0.00592	−7.34	−0.00595	−7.34
Korea	0.00125	3.31	0.00216	3.30	0.00357	3.65	0.00547	4.18
$sc_{i,t-x-1}$	0.93022	19.76	0.91129	12.47	0.90007	8.16	0.88813	7.47
$Merger_{i,t}$	0.00028	0.56	0.00384	5.31	0.00522	7.06	0.00505	5.17
$Merger_{i,t-1}$			0.00169	2.34	0.00326	5.15	0.00439	6.46
$Merger_{i,t-2}$					−0.00014	−0.13	0.00191	2.72
$Merger_{i,t-3}$							−0.00098	−0.66
$RJV_{i,t}$	0.00009	0.27	−0.00020	−0.38	−0.00085	−1.04	0.00069	0.64
$RJV_{i,t-1}$			0.00076	1.45	0.00117	1.53	0.00087	0.86
$RJV_{i,t-2}$					0.00114	1.46	0.00240	2.39
$RJV_{i,t-3}$							0.00124	2.23
Constant	−0.00010	−0.45	−0.00037	−1.00	0.00003	0.06	0.00059	0.87
R^2-adjusted	0.850		0.862		0.884		0.891	
No. Obs.	1,433		1,185		985		807	
Tests:								
Sum Merger coefs	0.00028	0.56	0.00553	5.58	0.00834	7.25	0.01037	7.31
Sum RJV coefs	0.00009	0.27	0.00056	0.74	0.00146	1.47	0.00520	3.33

Note: Estimation method is 2SLS with market share instrumented by patents accumulated in the semiconductor industry.

Table 3: An endogenous switching model: Estimates of system (11) to (13) for $x = 3$

	Mergers		RJVs	
	Coef	Coef/St.E	Coef	Coef/St.E
Selection equation:				
$(\widehat{sc_{m,i,t} - sc_{nm,i,t}})$	46.869	8.74	22.619	6.27
$\text{Patents}_{i,t}$	−0.74570	−2.58	0.17024	6.77
Deals_t	0.22708	1.49	0.67633	0.96
Firms_t	−0.48177	−1.36	−0.16133	−0.50
Corrected market share equation:				
$sc_{m,i,t-3}$	1.19063	13.06	1.09673	4.80
$sc_{nm,i,t-3}$	0.86296	105.18	0.87684	109.66
Variance parameters:				
Sigma (0)	0.61231		0.58548	
Rho(0, v)	0.87462		0.10481	
Sigma (1)	0.15911		0.15420	
Rho(1, v)	−0.36566		−0.10726	
Log likelihood function:	2358.7		1966.0	
No. Obs.	807		807	

Note: $(\widehat{sc_{m,i,t} - sc_{nm,i,t}})$ is the estimated difference in (combined) market shares between the two regimes; $\text{Patents}_{i,t}$ are the total number of patents accumulated of each firm in a given year; Deals_t are the total number of mergers and RJVs, respectively, in the semiconductor industry in a given year, and Firms_t are the total number of firms operating in a given year. Included in the selection equation but not reported are country dummies.