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# Horizontal mergers in the paper industry

**Martin Pesendorfer***

*I examine mergers and acquisitions in the U.S. paper and paperboard industry, which experienced a wave of horizontal mergers during the mid-1980s. I describe how the mergers affected investment decisions, costs, and consumers, finding that merged firms lose market share and are more likely to scrap capacity subsequent to an acquisition. I estimate a cost function for individual firms based on an investment model, finding that the efficiency of the majority of acquiring firms increases following an acquisition. Using the estimated cost function, I quantify welfare effects and find evidence of total welfare increases in some paper product categories as a result of the mergers.*

## 1. Introduction

■ Mergers and acquisitions have long been a public policy concern. In the United States, Section 7 of the Clayton Act prohibits mergers that "substantially decrease . . . competition or tend . . . to create a monopoly." In recent years, the volume of mergers and acquisitions in U.S. industries has increased. Antitrust regulators reviewed a total of 3,702 deals in 1997, compared to 1,451 in 1991.[1]

I study the implications of horizontal mergers in the paper and paperboard industry. A total of 31 horizontal mergers took place during the mid-1980s. Using data on investment decisions, I examine the effect on consumers, rival firms, and welfare. There are at least two reasons for examining investment: First, mergers alter the capital allocation within an industry, which affects investment decisions.[2] Second, investment is the main strategic choice variable in the paper industry.[3] I employ a firm-level dataset that permits a statistical analysis of merger implications. This article does not focus on the factors that may influence the decision to acquire another company.

Section 4 describes the paper industry and the wave of mergers that took place in the mid-1980s. A total of 31 mergers occurred in 3 years, immediately following the 1984 revision of the merger guidelines in which antitrust authorities adopted a friendlier position toward mergers. Therefore, I assume that the merger wave was not anticipated when investment decisions were

* London School of Economics; m.pesendorfer@lse.ac.uk.

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[1] *Business Week,* March 23, 1998, p. 35.

[2] Short-run price or output effects may mismeasure merger implications, since they do not take into account changes in investment.

[3] Paper and paperboard companies operate their plants at 93% of capacity on average during the sample period. Due to the high utilization level, production decisions are less important.

made in the early 1980s. Evidence on U.S. merger activity provides support for this assumption. This activity, as measured in the dollar value of acquisitions, increased by more than 100% between 1983 and 1985.[4]

I compare the period prior to the merger wave to the period after. Using the assumption that the merger wave was not anticipated in 1983, I contrast investment decisions of individual firms prior to and after the merger wave to assess changes in costs due to merger. Based on estimates of cost parameters, I can calculate merger welfare effects.

Section 3 describes the model. I consider a one-period investment game. The equilibrium decision rule implies that for a given level of capacity, efficient firms invest more than inefficient firms. Increased investments reflect higher efficiency, holding capacity levels constant. I use this equilibrium relationship to infer changes in efficiency following an acquisition. I also describe predicted merger implications in a linear-demand example. The example illustrates that a merger can be profitable even in the absence of cost savings, provided the cost of capital is high. Of course, an acquisition may achieve cost savings, enhancing the profitability of the acquisition. The welfare effects of mergers depend on the magnitude of cost savings. In the absence of cost savings, mergers reduce total welfare. On the other hand, when mergers do reduce costs, total welfare is increased.

Section 5 provides descriptive evidence on the effect of mergers between paper companies. The data suggest that merger outcomes are heterogeneous. About three-quarters of acquiring firms lose market share after the acquisition, while the others gain market share. An examination of investments reveals a similar picture: Merged firms are more likely to change their capacity levels than unmerged firms. There is dispersion, however, in that some acquiring firms reduce capacity while others increase.

Section 6 presents estimates of the equilibrium investment decisions, before and after the merger wave, to assess changes in firms' underlying cost parameters. The estimates indicate cost savings for most firms involved in a merger: The acquiring firm's cost decreases after the merger. Contemporaneous publications emphasize the importance of cost savings as a merger motive. As I shall describe, cost savings arise in a number of ways, including restructuring of the company, efficiency gains in the allocation of inputs, and reorganization of production. Based on the cost estimates, I calculate annual merger welfare effects. I also report the implications for firm profits and contrast the predicted effect with evidence on the shareholder wealth of publicly traded paper companies.

The next section discusses the related literature.

## 2. Related literature

■ The literature on mergers primarily considers short-run price or output effects. Deneckere and Davidson (1983) consider price effects in a differentiated-products model. Salant, Switzer, and Reynolds (1983), Baye, Crocker, and Jiandong (1996), Kamien and Zang (1990), Perry and Porter (1985), and Farrell and Shapiro (1990) consider the Cournot model. Salant, Switzer, and Reynolds (1983) establish that in the Cournot model with many firms, no profitable mergers may exist. Farrell and Shapiro (1990) examine welfare effects of mergers and provide sufficient conditions for a profitable merger to increase welfare.

Long-run effects of a single merger are examined in Stigler (1950) and Cabral (2003), who analyzes the profitability of mergers under entry. Stigler assumes that entry occurs gradually and the merged firm makes monopoly profit for a short time. He shows that merger for monopoly is profitable if the monopoly profit exceeds the future losses. Pesendorfer (2000) analyzes a repeated game with entry and mergers in every period, showing that a merger that leads to additional mergers in the future can be profitable in the long run although it is unprofitable in the short run. Berry

[4] According to *Grimm's Mergerstat Review* in 1992, the dollar value of acquisitions in constant 1992 dollars averaged $102.8 billion between 1981 and 1983, and $216.0 billion on average between 1985 and 1987.

and Pakes (1993), and Gowrisankaran (1995) study dynamic models of mergers using numeric methods. They analyze merger implications when output adjustment is costly.

There is little empirical research on the effects of horizontal mergers. Exceptions include Kim and Singal (1993) and Knapp (1990), who study the effect of airline mergers. Kim and Singal contrast price changes in routes affected by a merger to routes not affected by a merger. They find substantial price increases due to merger. Hall (1988) studies the effects of mergers on research and development for publicly traded U.S. manufacturing firms.

In comparison, the effects of mergers on shareholder wealth has been studied extensively. The evidence shows that shareholders of acquired firms gain, while the shareholders of acquiring firms do not lose. When the wealth effects of acquired and acquiring firms are combined, the joint value of firms involved in successful tender offers increases significantly. Agrawal, Jaffe, and Mandelker (1992) and Jarrell, Brickley, and Netter (1988) summarize the literature and present evidence on stock performance. Jensen (1986, 1988) and Scherer (1988) examine the motives for corporate mergers and discuss the empirical evidence on mergers.

The paper and paperboard industry has been studied by a number of authors. Recent articles include Ohanian (1994) and Christensen and Caves (1997). Christensen and Caves examine the role of cheap talk in announcing the construction of a new paper plant.

## 3. Investment model

■ In this section I describe the investment model. The first subsection describes the equilibrium investment decision. I illustrate how to infer costs from data on investment decisions based on the equilibrium investment equation. The second subsection defines expressions for consumer and producer surplus underlying the welfare analysis. The third subsection considers a specific example to illustrate implications of mergers. The profitability of mergers is examined and welfare implications are illustrated.

The model considered is one shot. In principle, dynamic aspects can be incorporated by extending the model to a repeated-game setting with the capacity level as a state variable. However, a dynamic formulation has two shortcomings: First, the data are available for a short time horizon only. Second, the state space of the dynamic model is rather complex because of the relatively large number of firms. The computation of a dynamic equilibrium is infeasible. For these reasons, I consider a static model.

The model has the following features. The industry consists of $n$ firms producing a homogeneous good. Firm $i$ is endowed with a level of capacity, $K_i$, and decides whether to invest in $x_i$ additional units of capacity (or to scrap capacity). Denote with $K = (K_1, \ldots, K_n)$ the vector of firm capacity levels, and with $x = (x_1, \ldots, x_n)$ the vector of investments. Capacity depreciates at a constant rate, $1 - \delta \in (0, 1)$. The capacity level of firm $i$ after the investment thus is given by $\delta K_i + x_i$. The cost of additional units of capacity, $x_i$, is denoted by $r(x_i)$ with derivative $r'(x_i)$. The production costs for firm $i$ are denoted by $C_i(K_i)$ with marginal cost $c_i(K_i)$.[5]

The inverse-demand curve is given by $P(Q)$, where $Q$ denotes industry output and $P$ industry price. Assume that firms operate at full capacity[6] and, thus, that total industry production equals the sum of capacities, $Q = \sum K_i$. Firm $i$ receives revenues $K_i \cdot P(\sum K_j)$, and I assume that the industry marginal revenue slopes down. I assume a common discount factor, $\beta \in (0, 1)$. Payoffs equal discounted future profits minus the cost of investment, as given by

$$\frac{\beta}{1-\beta}\left[(\delta K_i + x_i)P\left(\sum_{j=1}^{n}(\delta K_j + x_j)\right) - C_i(\delta K_i + x_i)\right] - r(x_i)\cdot 1_{\{x_i>0\}}, \tag{1}$$

where $1_{\{x_i>0\}}$ equals one if the investment of firm $i$, $x_i$, is positive.

[5] For simplicity of exposition, I do not consider uncertainty. Of course, i.i.d. shocks in cost or demand can be incorporated without changing the analysis.

[6] As mentioned in footnote 3, this assumption is reasonable for the paper industry.

□ **Investment decisions.** First let us characterize the equilibrium investment (scrapping) decision. Assume that a unique equilibrium exists and that the equilibrium investment decisions are characterized by the first-order condition. The marginal revenue of an additional capacity unit is denoted by $MR_i$. It is a function of the vector of existing capacities, $K$, the vector of investments, $x$, and the capacity, $K_i$, and investments, $x_i$, of firm $i$. Proposition 1 gives the Kuhn-Tucker equation characterizing the equilibrium investment decision.

*Proposition 1.* The equilibrium investment decision, $x_i$, is implicitly characterized by

$$x_i \cdot \left\{ [MR_i(K, x, K_i, x_i) - c_i(\delta K_i + x_i)] \frac{\beta}{1-\beta} - r'(x_i) \cdot 1_{\{x_i > 0\}} \right\} = 0. \tag{2}$$

The discounted marginal benefit of investment equals the marginal cost. Firms with a positive marginal benefit purchase additional units of capacity, while firms with a negative benefit reduce capacity. If $r'(x_i) \neq 0$, there may also be a subset of firms that do not invest or scrap.

Observe that a dynamic formulation will yield an investment equation similar to (2). For the special case with $\delta = 1$ and $r(x) = r \cdot x$, the equilibrium of the dynamic game coincides with (2). The reason is that in this case, investments take place immediately. If nobody delays, then any profitable investment undertaken at some point in the future will yield even more profit if it is undertaken a little earlier.

Equation (2) implicitly determines the productive efficiency of individual firms. For a given level of capacities, firms that invest more have lower marginal cost. My empirical strategy is to identify the unobserved marginal-cost parameters of firms based on the equilibrium investment decision. Estimating unobserved marginal-cost variables by inverting a structural equation has been used in the literature in a number of places. Recent examples include the industry studies using the Cournot model surveyed in Bresnahan (1989), auctions in Paarsch (1992), and investments in Olley and Pakes (1996). In contrast to the Cournot literature, I identify marginal costs based on two firm-specific variables: investment decision and capacity.

Corollary 1 expresses the marginal cost of firm $i$ as a function of capacity levels, investment decisions, and the cost of capacity.

*Corollary 1.* If $x_i \neq 0$, then the marginal cost of firm $i$ is given by

$$c_i = MR_i(K, x, K_i, x_i) - r'(x_i) \cdot \frac{1-\beta}{\beta} \cdot \mathbf{1}_{\{x_i > 0\}}. \tag{3}$$

If $x_i = 0$, then the marginal cost, $c_i$, is contained in an interval:

$$c_i \in [MR_i(K, x, K_i, x_i) - r'(x_i)[(1-\beta)/\beta]\mathbf{1}_{\{x_i > 0\}}, MR_i(K, x, K_i, x_i)].$$

The variables in (3) include industry capacity, industry investments, the capacity level and investment choices of firm $i$, the cost of additional capacity, and the discount factor. If these data are available, then the marginal production cost can be inferred.

□ **Welfare measures.** Consumer surplus is defined as the difference between the willingness to pay and the price paid. Let $Q = \sum K_j$ denote the industry output. Consumer surplus can be written as

$$CS(Q) = \int_0^Q P(x)dx - Q \cdot P(Q). \tag{4}$$

Producer surplus is defined as the difference between the price paid and the production cost, and it is given by

$$PS(K, x) = \sum_i [K_i P(Q) - C_i(K_i) - r(x_i)1_{\{x_i > 0\}}]. \tag{5}$$

The total welfare effect of mergers and acquisitions is, thus, given by changes in the sum of $CS$ and $PS$.

□ **Merger example.** Next I illustrate implications for acquisitions and mergers in an example. I make a number of additional assumptions to simplify the analysis and to illustrate the merger implications analytically.

A merger combines two (or more) firms and takes place prior to the investment stage. The merged firm's capacity equals the sum of the capacities of individual components. After the merger, firms may invest to adjust their capacities to the new industry configuration.

The model is formulated using a set of parameters that will be employed in the empirical analysis. In this section I make a number of additional assumptions to keep the analysis tractable.

*Assumption 1.* The following conditions are satisfied:

(i) Demand is linear: $P(Q) = A - bQ$.
(ii) $\beta/(1-\beta) = \delta = 1$.
(iii) Unmerged firms have constant and identical marginal cost, $c_i = c$. The merged firm has constant marginal cost $c_m$.
(iv) The cost of investment is linear, $r(x) = r \cdot x$.
(v) Initial capacities are at Cournot levels, $K_i = (A - c)/b(n + 1)$.

Assumption 1(ii) normalizes the discount factor and the rate of depreciation. This has no qualitative effect on the analysis. Assumption 1(iii) requires that all unmerged firms have constant and identical marginal cost. Assumption 1(v) states that capacity levels are at symmetric Cournot levels calculated in the absence of investment costs.

The following remark considers the profitability of mergers in the absence of cost savings. It provides a condition for profitable mergers to exist. Proofs for all remarks are given in Appendix A.

*Remark 1.* Suppose the marginal cost of the merged firm equals the premerger level, $c_m = c$. Then, for any $n$, such that $2(n + 1) > (A - c)/r$, a merger is profitable.

Remark 1 establishes that even in the absence of cost savings, mergers may be profitable. With sufficiently many firms, or, alternatively, when the cost of investment is high, there are gains to industry consolidation. This finding contrasts with the Cournot model, for which Salant, Switzer, and Reynolds (1983) show that, given constant marginal costs and linear demand, mergers are not profitable (other than merger for monopoly).[7] The reason for the profitability of mergers is an asymmetry between capacity expansions and reductions in the investment model. Capacity expansions are costly whereas capacity reductions are not. This asymmetry gives the merged firm an advantage, and when the cost of additional capacity is high, mergers may be profitable. Of course, cost savings due to mergers may additionally enhance the profitability of mergers, as has been established by Perry and Porter (1985).[8]

Next I consider the implications of a merger. The following remark illustrates that no changes in investment policies after the merger indicate merger cost savings.

*Remark 2.* Suppose the merged firm does not invest after the merger, $x_m = 0$. Then, the marginal cost of the merged firm is below the marginal cost of unmerged firms, $c_m < c$.

The argument is the following: The comparison of the equilibrium investment decision in (2) before and after the merger reveals that to achieve investment levels equal to the premerger

[7] Observe that the model of Salant, Switzer, and Reynolds is the limiting case of the conditions in Remark 1, as $r \to 0$. In the limit, with $r = 0$, mergers are unprofitable (other than merger for monopoly).

[8] Perry and Porter consider a model in which cost is a function of the capital stock and output of the firm. They assume constant returns to scale. An implication of this assumption is that the marginal cost decreases in the capital stock of the firm. A merger, which combines the capital stock of the individual component firms, may yield a lower marginal cost to the combined firm.

level, the firms must cut costs substantially. The reason is that the marginal revenue of investment, $MR_i(K, x, K_i, x_i)$, declines after the acquisition of additional capacity. This decline has to be offset by a decline in marginal production cost.

In the following, I discuss welfare implications of mergers. I distinguish two cases: where there are cost savings due to merger and where there are no cost savings. Remark 3 discusses the latter case.

*Remark 3*. Suppose the marginal cost of the merged firm equals $c$ after the merger. Then the merger reduces welfare.

In the absence of merger cost savings, the profitability of a merger requires that output decline. Since firms have identical marginal costs, this results in a welfare loss.

On the other hand, under the presence of merger cost savings, a merger may increase welfare. In this case, the cost savings result in an increase of producer surplus. For small effects on consumer surplus, this may yield a net increase in total welfare. The following remark states that no changes in investment policies after the merger imply welfare increases.

*Remark 4*. Suppose the merged firm does not invest after the merger, $x_m = 0$. Then a merger increases welfare.

If the merged firm maintains or increases its market share subsequent to the merger, then the merger must yield cost savings and welfare increases. The prediction can be examined directly in the data.

## 4. Acquisitions in the paper industry

■ This section provides background information on the paper and paperboard industry. It presents the data and provides summary evidence about investment decisions. In addition, I describe the wave of mergers that occurred in the mid-1980s.

□ **The data.** I collected data on annual production capacity of individual paper and paperboard producing firms between 1978 and 1992. The data were obtained from *Lockwood's Directory of Paper and Allied Trade.* This publication gives the following information on every paper plant operating in the United States: the location of the plant (town and state); the company operating the plant; the mill status (operating, idle, remodelled); the products produced at the mill; and production capacity by product. In addition, the data are supplemented with price data for individual paper products obtained from the Census Bureau.

The data divide paper products into nine categories: newsprint, packaging papers, groundwood printing, coated papers, uncoated papers, other papers (bleached bristol, cotton fiber, and thin paper), tissue, linerboard, and boxboard. Products within a category are largely homogeneous. An exception are tissue products, where brand names appear important.

Paper machines are specialized, typically producing one category of paper exclusively. According to the data, about 80% of capacity is attributable to plants producing only a single paper category.[9] It is costly to reconfigure a paper machine producing one product category so that it can produce another.[10] Therefore, I expect little spillover, or externalities, in production between paper categories and assume that individual paper categories constitute independent markets.

I select the United States as a geographic market. This market definition may appear narrow for an exporting industry. In 1991, which is at the end of my sample period, about 15% of U.S. production was exported and the share of imports was about 12%. An exception is newsprint, where about 50% of capacity is imported from Canada. I therefore drop newsprint from the

[9] The remaining 20% is produced in plants producing multiple categories. I use the share of individual categories in total capacity to construct a capacity variable for each product whenever this information is available in the data. In a number of cases the share data are missing. In those cases I assume equal shares for all listed product categories.

[10] *Georgia-Pacific Corp.: Corporate Strategy*, Harvard Business School Case, no. 9-391-174, 1991.

**TABLE 1 Summary Statistics of the Paper Industry**

| Year (1) | Industry Growth Rate (2)=(3)+(4) (2) | Growth Rate Contribution by: Firms[a] That Expand Capacity (3) | Growth Rate Contribution by: Firms[a] That Reduce Capacity (4) | Growth Rate Contribution by: Building a New Plant (5) | Growth Achieved at Firms by Horizontal Merger (6) | Average Number of Firms per Product Category (7) |
|---|---|---|---|---|---|---|
| 1978 | — | — | — | — | — | 70.6 |
| 1979 | 1.32 | 2.91 | −1.59 | 1.10 | .79 | 70.4 |
| 1980 | −.09 | 3.24 | −3.33 | .26 | 2.25 | 69.5 |
| 1981 | 2.30 | 4.58 | −2.28 | .89 | .67 | 67.6 |
| 1982 | 1.56 | 3.97 | −2.41 | 1.14 | 1.46 | 66.6 |
| 1983 | .64 | 3.67 | −3.03 | .09 | 2.12 | 65.6 |
| 1984 | −1.47 | 3.45 | −4.92 | .29 | 1.72 | 64.7 |
| 1985 | .99 | 2.76 | −1.77 | .38 | 5.83 | 63.6 |
| 1986 | .19 | 3.61 | −3.42 | .34 | 7.43 | 62.3 |
| 1987 | 3.14 | 4.09 | −.95 | .50 | 5.83 | 61.1 |
| 1988 | 1.96 | 4.56 | −2.60 | .00 | 1.84 | 60.2 |
| 1989 | 1.76 | 4.47 | −2.71 | .92 | 2.15 | 58.7 |
| 1990 | 1.21 | 2.64 | −1.43 | .34 | 5.13 | 56.6 |
| 1991 | 3.39 | 4.45 | −1.06 | .35 | 1.78 | 59.8 |
| 1992 | 2.82 | 3.58 | −.76 | .69 | 1.69 | 60.4 |

[a] Excluding capacity acquired by an acquisition or merger.

analysis. On the other hand, the market definition may appear too broad given high transportation costs, which are estimated to be 9% of the value of shipments[11] even though between 40% and 70% of paper products travel fewer than 500 miles. (See Christensen and Caves (1997).)

□ **Industry summary statistics.** Table 1 provides summary statistics for the paper and paperboard industry. The average number of firms per paper category is given in column 7 of Table 1. The number of firms shrinks from about 70 in 1978 to about 60 in 1992. Despite the relatively large number of firms, there is substantial concentration. The capacity accounted for by the largest five firms averages 56.1% across paper categories in 1992. The highest five-firm concentration is for tissue products, 75%. The lowest five-firm concentration is in newsprint, 41%.

Total industry capacity increased by about 20% between 1978 and 1992. Growth rates, which are on average .7% before 1987, increase to an average of 2.4% after the merger wave, starting in 1987.

Individual firms exhibit substantial variation in their investment strategies. Columns 3 and 4 in Table 1 report investment decisions for two groups of firms: firms that expand industry capacity and firms that reduce it. Every year, about 20% of paper companies increase their production capacities. Capacity expansions account for an average industry growth rate of 3.7% per year.[12] On the other hand, capacity reductions decrease the industry growth rate by 2.3% per year. The difference, or the net annual industry growth rate, is 1.4%.

Capacity at existing plants is mostly expanded by improving the speed of the machines. Faster machine speed directly translates into more output. According to Biermann,[13] the maximum paper machine speed increased by 17% between 1981 and 1991, on average, across product categories. New plant construction accounts for a small share of capacity growth. Column 5 in Table 1

[11] *Pulp and Paper*, Vol. 65 (October 1991), pp. 50–55.

[12] Capacity expansions (or reductions) due to merger are not included in columns 3 and 4.

[13] Calculated from Table 9.1 in C.J. Biermann, *The Essentials of Pulping and Papermaking,* San Diego: Academic Press, 1993, p. 210.

illustrates that fewer than 15% of capacity expansions are achieved through building a new plant (or machine).

□ **Horizontal mergers.** Horizontal mergers and acquisitions constitute an important contribution to firm-level growth. Column 6 indicates that in total, about 40% of the capacity expansions at existing firms are achieved through horizontal acquisitions. An examination of ownership changes for individual paper plants indicates the magnitude of the merger phenomenon. About 40% of the 819 paper and paperboard plants operating in the United States between 1978 and 1992 were involved in at least one merger. Dividing the sample into horizontal mergers, in which both acquiring and acquired firm are paper companies, and "unrelated mergers" reveals that more than two-thirds of the merged plants are involved in a horizontal merger.

Firms involved in acquisitions tend to be among the largest in the industry. In more than half the mergers during the sample period, the acquiring firm is among the top 15% of firms in the size distribution. Moreover, the acquired firm is among the top 25% of firms in the size distribution in those cases.

Merger activity was substantially higher during the years 1985–1987. In 1986, the industry publication *Pulp and Paper* called this wave of mergers a "restructuring of the industry." A total of 31 mergers and acquisitions took place between August 1984 and July 1987. This three-year period accounts for about half the total capacity involved in a merger between 1978 and 1992. Appendix B lists the acquiring and acquired firms, the acquisition date, and the dollar amount. The largest were Jefferson Smurfit Corporation's acquisition of Container Corp. for $1.2 billion, International Paper's acquisition of Hammermill for $1.1 billion, and Champion International Corporation's acquisition of St. Regis for $1.8 billion.

During this three-year period, there is at least one merger affecting every product category. Table 2 reports the number of acquiring and acquired firms for individual product categories. The total number of acquiring firms exceeds 31 in Table 2 because some mergers affect more than one product category.

The merger wave among paper companies had a substantial impact on the industry. On average, the number of paper companies per product category shrank from about 65 in 1984 to about 60 in 1988.

□ **Expected merger effects.** We may expect two opposing effects due to horizontal mergers and acquisitions: First, mergers may have anticompetitive effects on price and investment. James River was blocked from acquiring Barlow Rand by the Federal Trade Commission in February 1988. The FTC argued that the merger would reduce competition for certain types of packaging materials.

Second, mergers may reduce costs. The statement made by Mr. Crump, the executive vice president of Great Northern Nekoosa, concerning the acquisition of Owens Illinois illustrates the importance of the claimed cost savings: "The synergistic effects of this acquisition are immense and we are already reaping the benefits."[14] In recent years, companies report expected cost savings associated with a planned acquisition. The merger between Kimberly-Clark and Scott Paper provides an example. Kimberly-Clark announced expected cost savings of $250 million in the first year after the acquisition, $400 million in the second year, and $500 million thereafter. According to newspaper reports, the cost savings are achieved by restructuring the company and by closings of headquarters and offices. However, there is little evidence that these cost savings are actually realized.

According to reports detailing the expected effects of paper mergers, cost savings are achieved in a number of ways: First, savings may be achieved through reorganization of production. Within a paper category, a number of different grades can be produced that differ by weight, color, and texture. A machine is more efficient the narrower the range of grades it produces. For example,

[14] *The New York Times,* November 6, 1987, p. D2.

**TABLE 2** **Number of Acquiring and Acquired Firms Between August 1, 1984, and July 17, 1987**

| | Product Category | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Variable | Packaging Paper | Groundwood Printing | Coated Papers | Uncoated Papers | Other Papers | Tissue | Boxboard | Linerboard |
| Number of acquired firms | 11 | 3 | 8 | 10 | 2 | 2 | 7 | 11 |
| Number of acquiring firms | 10 | 2 | 7 | 9 | 2 | 1 | 7 | 10 |

a grade of uncoated freesheet may cost 20–30% less to produce on a machine that is configured especially for that grade than on a machine configured to accommodate a wide variety of grades.[15] In addition, machines operate more efficiently the longer the production runs, since grade changes are costly.

Second, merger allows companies to buy inputs at lower prices. Also, because companies are vertically integrated, supplying inputs such as timber and pulp, combining two companies may yield a more efficient allocation of inputs. The merger between Georgia-Pacific and Great Northern Nekoosa provides an example. According to *The New York Times,* February 16, 1990, p. D8, the chairman of Georgia-Pacific remarked that "Georgia-Pacific had two plants in Georgia that produce finished cardboard boxes, but no plant in the state that produces linerboard, the basic raw material for the boxes. It currently pays to have linerboard shipped to Georgia from its plant in Mississippi. Great Northern Nekoosa has a linerboard plant in Georgia."

Third, gains are achievable by combining the sales and distribution forces of the companies. A single distribution network may operate more effectively than two distribution networks separately. Thus, a merger may eliminate duplications. In the case of the merger between International Paper and Hammermill, according to *The New York Times,* August 12, 1986, p. D1, "in addition to improving its product mix, International Paper was said to be interested in acquiring Hammermill's marketing skill."

The next section focuses on contrasting the decisions of merged and unmerged firms. It provides a description of the data and it studies changes in market shares and in investment behavior following a merger. This analysis may provide evidence for cost reductions stemming from mergers.

## 5. Merger effects

■ This section describes the effects of mergers and acquisitions on annual investment decisions between 1978 and 1992. I examine changes in market share and document the effect on investment decisions.

Table 3 describes the percentage of merged firms that lose market share subsequent to an acquisition. I examine the sum of the shares of the acquiring and acquired firm subsequent to a merger or an acquisition for the period between 1978 and 1992 for individual paper categories. On average across categories, 53.7% of firms lose market share after two years. After five years in all but one category, more merged firms lose market shares than gain. On average across categories, 74.1% of firms lose market share. Thus, although most merged firms lose market share, there is a dispersion in outcomes. Some firms gain market share subsequent to an acquisition while others lose market share.

An OLS regression with the market share of the merged firm as dependent variable and the time since acquisition and time squared as explanatory variables shows that as time since the merger increases, the average market share falls at a decreasing rate. Pooling the data across all product groups, I find that the low occurs after about 5 years at 90% of the initial market share. A

[15] *Georgia-Pacific Corp.: Corporate Strategy*, Harvard Business School Case, no. 9-391-174, 1991.

**TABLE 3 Percentage of Merged Firms That Lose Market Share After Acquisition**

| | Product Category | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Time after Acquisition | Packaging Paper | Groundwood Printing | Coated Papers | Uncoated Papers | Other Papers | Tissue | Boxboard | Linerboard |
| Two years after | 41.0 | 80.0 | 52.8 | 55.0 | 55.6 | 47.6 | 39.4 | 58.1 |
| Five years after | 71.4 | 100.0 | 82.6 | 83.3 | 83.3 | 76.5 | 34.6 | 61.3 |

Data include market shares of acquiring firms between 1978 and 1992.

similar picture emerges for individual product categories. Entry in the industry does not explain the falling market shares of merged firms, as there was little entry during the period of study.

The decline in market share for the average merged firm may suggest that acquisitions result in modest cost savings, or none at all. However, Table 3 shows there is variation in merger outcomes. Remark 2 in Section 3 states that firms that do not scrap capacity after a merger achieve cost savings. Although the remark relies on strong assumptions, it suggests that at least a quarter of acquiring firms achieve cost savings after five years. Similarly, Remark 4 suggests that at least a quarter of mergers may lead to welfare increases.

I next examine the annual investment decisions of individual firms. The raw data indicate that merging firms are more likely to change their capacity level than nonmerging firms. Firms that acquired another firm during the past five years invest on 32.86% of occasions, while they scrap capacity on 19.76%. On the other hand, firms that were not involved in a merger in the past five years invest on 16.17% of occasions and scrap capacity on 5.54%.

Table 4 reports estimates of a multinomial logit model. The decisions to scrap existing capacity and to invest in capacity are considered. I also considered an ordered probit model but report the multinomial logit specification, as it achieved a better fit measured by the $\chi^2$ level. I report estimates using pooled data across paper categories. In every

**TABLE 4 Investment Decisions**

| | Dependent Variable | |
|---|---|---|
| Variable | $\text{SCRAP}_{x_i}$ $i < 0$ | $\text{INVEST}_{x_i}$ $i > 0$ |
| MERG-SIZE | 1.9112 | 1.0243 |
| | (1.9) | (1.0) |
| MERG-2-5 | 1.7027 | .7922 |
| | (2.7) | (1.7) |
| PLANTS | .1557 | .5289 |
| | (.5) | (2.2) |
| $\text{PLANTS}^2$ | .0135 | −.3121 |
| | (.1) | (2.3) |
| PRODUCTS | −.16 | −.1221 |
| | (2.1) | (2.6) |
| $\text{PRODUCTS}^2$ | .0413 | .0289 |
| | (6.2) | (6.6) |
| Estimation method | Multinomial logit | |
| Number of observations | 9,352 | |
| Degrees of freedom | 9,294 | |
| $\chi^2$ | 828.7 | |

All variables in logarithms. Absolute values of $t$-statistics displayed in parentheses. Each regression includes a set of year-specific dummies and a set of product dummies.

year, I consider the set of currently active firms. This selection is unlikely to bias estimation because entry and exit are of small magnitude in the paper industry.

Explanatory variables include MERG-SIZE, which measures the ratio of the capacity of the acquired firm to that of the acquiring firm. MERG-SIZE equals zero if there was no merger. MERG-2-5 is a dummy variable that equals one if the firm acquired another paper company 2 to 5 years preceding the merger. The variable PLANTS measures the number of plants and PRODUCTS the number of product categories produced by the firm.

About 24% of firms change their capacity every year, and in about three out of four instances capacity is expanded. Table 4 suggests that larger firms are more likely to expand capacity. The linear coefficient of PLANTS is positive and the quadratic coefficient is negative for investment decisions. Larger firms are also more likely to scrap existing capacity, but the effect is not significant. The variable PRODUCTS has a different effect. As the number of product categories increases, firms are less likely to invest in or to scrap capacity.

Mergers have significant effects on scrapping decisions. The effects of MERG-2-5 and MERG-SIZE are both positive and significant for the decision to scrap capacity. MERG-2-5 and MERG-SIZE also have a positive effect on the decision to invest, but the effect is significant only for MERG-2-5, and even there the significance is marginal.

The estimates suggest that mergers increase the probability of scrapping capacity. The probability of investing is also increased at least for MERG-2-5. The increased probability of scrapping and investing suggests a dispersion in investment decisions across acquisitions.

In summary, the descriptive data analysis suggests that three-quarters of acquiring firms witness market share declines five years after the merger. The example in Section 3 suggests that the remaining quarter of the acquiring firms achieve cost savings. Second, investment decisions reveal a similar picture: Merged firms are more likely to change capacity levels than do other firms. However, there is dispersion across merged firms, as some acquiring firms reduce capacity while others increase. The next section uses the investment model to draw inferences about the magnitude of cost savings.

## 6. Estimation results

■ This section reports cost and welfare implications of mergers. The previous section looked at the period between 1978 and 1992. Here I focus exclusively on the merger wave that took place between August 1984 and July 1987.

As noted above, the estimation of the equilibrium investment decision rule prior to the merger wave assumes that firms did not take into account possible future mergers. For example, firms are assumed to assign a negligible probability to triggering of a merger wave. This is reasonable if, in the early 1980s, firms did not anticipate changes in the position of antitrust authorities, as manifested in the 1984 guidelines.[16]

□ **Demand estimates.** I follow the literature on homogeneous product demand estimation and adopt a constant elasticity specification. I denote the inverse-demand elasticity with $\gamma$ and specify the inverse-demand equation as

$$\ln(P_t) = \alpha_0 + \alpha_1 d_t + \gamma \ln(Q_t) + u_t, \tag{6}$$

where $d$ denotes observed demand shifters, $Q$ denotes total output, and $u_t$ follows an AR(1) process,

$$u_t = \rho u_{t-1} + v_t, \qquad |\rho| < 1.$$

The endogenous variables are $P$ and $Q$, while the exogenous data, $z_t$, include instruments for the endogenous variable $Q$. I use gross domestic product as a demand shifter, $x_t$, and wood prices

[16] The model can be estimated under the assumption that firms anticipated the merger wave, but I find this assumption implausible.

**TABLE 5 Demand Estimates**

| | Product Category | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Packaging Paper | Groundwood Printing | Coated Papers | Uncoated Papers | Other Papers | Tissue | Boxboard | Linerboard |
| Constant | .072 | −.631 | .207 | .276 | .074 | −.042 | .278 | .642 |
| | (.12) | (.31) | (.02) | (.04) | (.02) | (.03) | (.09) | (.14) |
| $\alpha$ | 1.415 | .937 | 1.055 | 1.641 | 1.596 | 1.400 | 1.949 | 1.841 |
| | (.19) | (.20) | (.11) | (.23) | (.27) | (.18) | (.44) | (.50) |
| $\gamma$ | −.579 | −.081 | −.339 | −.810 | −.634 | −.536 | −.985 | −.955 |
| | (.15) | (.19) | (.10) | (.19) | (.19) | (.16) | (.33) | (.39) |
| $\rho$ | .52 | .13 | .81 | .72 | .79 | .56 | .62 | .52 |
| Number of observations[a] | 18.00 | 12.00 | 20.00 | 20.00 | 19.00 | 12.00 | 21.00 | 21.00 |

[a] Varies due to missing values. Standard errors in parentheses.

and wages of paper industry workers as instruments for $Q$. The data consist of annual output and price data for each product category between 1973 and 1993.[17]

The demand equation is estimated using a two-step procedure. In the first step $\rho$ is estimated based on residuals obtained from a two-stage least-squares regression of the demand equation (6) using instruments for the endogenous variable $Q$. In the second step, the coefficients in equation (6) are estimated, using the full GLS transformation. The method is more efficient than the Cochrane-Orcutt transformation for small sample sizes. The properties of the method are discussed in Harvey (1990).

Table 5 reports estimates of the demand equation for each category. The variable $Q$ measures U.S. production for an individual paper category between 1973 and 1995. The number of observations vary across paper categories due to missing values. An examination of the estimates in Table 5 reveals that demand elasticities are negative in all paper categories. The coefficients have about the expected magnitude. The inverse-demand elasticities range between −.081 and −.985 across paper categories. The inverse elasticities are not precisely estimated, which may be attributable to a lack of quality of the price or output series. In addition, the number of observations is small.

There is a concern that wages may be endogeneous due to unionization in this industry. To address this concern, I apply the Hausmann (1983) test of instrument exogeneity in the second-stage regressions. I test both the exogeneity of wood price using only wages as instruments and the exogeneity of wages using wood price as instruments. In both cases, the null of exogeneity cannot be rejected at the 1% level.

□ **Cost estimates.** According to industry publications, it takes between two and three years before capacity investments become productive. I select two-year windows, 1979–81, 1981–83, 1987–89, 1989–91, and 1991–93, to measure investment decisions and to infer marginal-cost parameters. Based on equation (3), I specify marginal cost of firm $i$ in period $t$, which equals the marginal revenue minus the investment costs, as a function of observable firm characteristics:

$$c_{it} = \alpha_2 + \alpha_3 K_{it} + \alpha_4 K_{it}^2 + \alpha_5 NP_{it} + \alpha_6 z_{it} + \varepsilon_{it}, \tag{7}$$

where the firm characteristics include capacity, capacity squared, the number of plants, NP, a set of firm- and time-specific dummies, $z_{it}$, and measurement error, $\varepsilon_{it}$. Provided $x_{it} \neq 0$, the marginal cost of firm $i$ in period $t$ is given by

[17] The data are listed in the section entitled "Statistics of the Industry" in *Lockwood's Directory of Paper and Allied Trade.* The price data were supplemented with price series published by the Bureau of Labor Statistics, http://www.bls.gov/data/sa.htm.

$$c_{it} = (\hat{P}(Q_t) - \frac{\partial \hat{P}(Q_t)}{\partial Q} \cdot [\delta K_{i,t-1} + x_{it}]) - r'(x_i) \cdot (1 - \beta)/\beta \cdot 1_{\{x_i > 0\}}.$$

Corollary 1 shows that the marginal cost is identified only if $x_{it} \neq 0$. When $x_{it} = 0$, I obtain a range of marginal costs instead. I avoid the nonidentification of marginal costs by assuming a positive depreciation rate that guarantees identification for all my observations. In the determination of marginal revenues, the predicted price, $\hat{P}_t$, is calculated using equation (6).

The marginal-cost estimates depend on the discount factor, $\beta$, the depreciation rate, $\delta$, and the marginal cost of additional capacity, $r'(x_i)$. I assume that the annual discount factor equals .95. Observe that an upward shift in the function $r'(x_i)$ implies a one-for-one downward shift in marginal cost. Thus, the cost of additional capacity cannot be inferred in equation (7). Instead, I infer the cost of additional capacity based on data on the costs of investment projects reported in the industry publication *Pulp and Paper*. This publication describes selected investment projects. It reports the change in production capacities and their dollar cost. Between the years 1987 and 1989, five projects are described. The cost ranges between \$600 and \$1,750 per ton, with an average cost of \$1,300 per ton in 1986 dollars. I use these data to obtain a base estimate of the cost of additional capacity using a linear and a quadratic specification. The estimates yield $r(x)(1 - \beta)/\beta = 26.5x + .005x^2$. The estimates are not precise, since the number of described projects is small. Therefore, I conducted a robustness analysis of the estimates of equation (7) varying the cost of investment. The different specifications permit me to assess the sensitivity of estimates with respect to the cost of additional capacity. Similarly, the decay parameter cannot be inferred from equation (7), and I assume a baseline $\delta = .999$. I conduct a robustness analysis of the marginal-cost estimates varying the decay parameter.

Table 6 reports estimates of marginal costs per ton of paper produced for individual paper categories. Explanatory variables include capacity, capacity squared, and the number of plants. A set of firm-specific dummies and time-specific dummies are included but not reported.

The effect of the number-of-plants variable is negative in all specifications, except for the category boxboard. The linear capacity term is negative and the quadratic term is positive for five product categories. Thus, as capacity increases, marginal production cost falls at a declining rate. For two product categories, both terms are negative. Thus, as capacity increases, cost falls at an increasing rate for two product categories. For groundwood printing, the quadratic term is negative and the linear term is positive. The linear term is small and not significant. Thus, as capacity increases, cost falls at an increasing rate.

The $R^2$ in Table 6 ranges between .991 and .999. This means that there is very little residual variation in costs across periods after taking into account the reported variables and firm fixed effects and time fixed effects.

**TABLE 6 Estimates of Marginal Cost**

| | Product Category | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Packaging Paper | Groundwood Printing | Coated Papers | Uncoated Papers | Other Papers | Tissue | Boxboard | Linerboard |
| Capacity[a] | −1.910 | .003 | −.910 | −.922 | −6.142 | −2.504 | −4.878 | −1.543 |
| | (.12) | (.51) | (.05) | (.10) | (1.36) | (.20) | (.19) | (.05) |
| Capacity$^2$ | .009 | −.009 | −.002 | (.004 | .082 | .020 | .027 | .003 |
| | (.00) | (.00) | (.00) | (.00) | (.00) | (.00) | (.00) | (.00) |
| Number of plants | −2.564 | −2.384 | −1.996 | −5.439 | −9.203 | −5.299 | 5.564 | −0.631 |
| | (.66) | (5.69) | (.75) | (.62) | (3.23) | (.75) | (.62) | (.41) |
| $R^2$ | .999 | .991 | .996 | .994 | .995 | .996 | .998 | .999 |
| Number of observations | 431.00 | 130.00 | 352.00 | 401.00 | 134.00 | 304.00 | 411.00 | 527.00 |

[a] Divided by a factor of ten. Standard errors in parentheses. A set of time and firm dummies are included but not reported.

An $F$-test to determine whether firm fixed effects are significant would reject the null of no firm-specific effects for all product categories at the 5% level. For seven out of eight categories, I reject the null at the 1% level.

The results in Table 6 remain qualitatively very similar as I vary the specification for the cost of additional capacity and the depreciation rate of capacity. The results of alternative specifications are reported in Pesendorfer (2000). I summarize the main implications: A lower depreciation rate, $\delta = .95$, results in marginal production cost estimates lower than in Table 6. Thus, the effect of capacity and number of plants is amplified relative to Table 6. If we consider a specification with a higher cost of investment, $r(x)(1 - \beta)/\beta = 36.5x + 0.007x^2$, then the effect of capacity and number of plants is amplified relative to Table 6, yielding lower cost estimates. If we assume that the cost of investment has a steeper slope than in Table 6 but the cost has no curvature, $r(x)(1 - \beta)/\beta = 53x$, then again the effect of capacity and number of plants is amplified, yielding lower marginal-cost estimates.

□ **Cost synergies.** The estimates of marginal costs permit an examination of the presence of cost synergies after an acquisition. Cost synergies can be manifested in the capacity coefficient, that of the number of plants, and the firm fixed effect.

A merger combines two capacity stocks. The cost estimates indicate that an increase in capacity leads to lower marginal cost, all else equal. This effect is evident for all product categories.

A merger also leads to an increase in the number of plants. For seven out of eight product cagetories, this leads to a reduction in the marginal cost. The exception is boxboard.

To examine the effect on firm fixed effects, I include separate dummies for the acquiring firm prior to and subsequent to acquisition. A qualitative comparison indicates whether the cost savings equal the average cost savings due to increased capacity. I find that in 75% of the mergers, the acquiring firm's fixed effect is higher after the acquisition. Thus, the average merger cost savings are less than the average savings based on the capacity increase. For the remaining quarter of the acquisitions, cost savings exceed the expected cost savings based on capacity.

The magnitude of cost synergy estimates remains qualitatively very similar as I vary the specification for the cost of additional capacity and the depreciation rate of capacity. I summarize the changes: A lower depreciation rate, $\delta = .95$, or a higher cost of investment, $r(x)(1 - \beta)/\beta = 36.5x + .007x^2$, amplifies cost synergies estimates. If we assume that the cost of investment has a steeper slope but the cost has no curvature, $r(x)(1 - \beta)/\beta = 53x$, then again the cost synergies increase in magnitude.

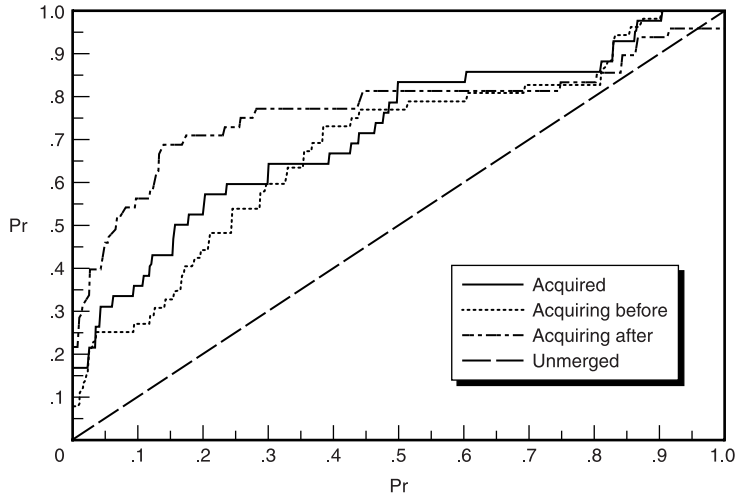
In summary, I find that, all else equal, marginal cost falls subsequent to an acquisition due to an increase in the capacity and an increase in the number of plants. Examining individual mergers reveals that there is a dispersion in merger outcomes. About one-fourth of mergers exceed the expectations and achieve additional cost savings, while three-fourths are below the expected effect.

Differences in marginal cost before and after the merger wave may also be illustrated by the distribution of marginal costs. I assign every marginal-cost estimate for merging firms to the corresponding percentile in the distribution of marginal costs of unmerged firms. Figure 1 depicts the distribution of marginal-cost estimates of acquiring firms before and after the acquisition. In addition, the distribution of marginal-cost estimates of acquired firms is reported. The first-stage estimation error of the demand parameters affects firms' cost estimates and does so symmetrically. Hence, a variation in the first-stage parameters results in a simultaneous shift and/or rotation of all marginal costs while maintaining the qualitative features of the marginal-cost distribution functions. To keep the illustration simple, I depict the distribution of point estimates only. The next subsection will report welfare estimates that take the first-stage estimation error into account. Due to the small number of acquisitions per product category, and since the majority of acquisitions affect only one product category, I report estimates pooled across product categories.

Figure 1 reveals that before the merger, 35% of acquiring firms are as efficient as the most efficient decile of unmerged firms, whereas after the merger, 55% of acquiring firms are as efficient as the top decile of unmerged firms. Thus, acquiring firms are relatively efficient firms and more

FIGURE 1

COST SYNERGIES




so after the merger. A similar picture emerges in comparison to the top quartile of marginal-cost estimates of unmerged firms. Before the merger, about 60% of acquiring firms have marginal-cost estimates that place them among the top quartile of unmerged firms, and this number increases to about 75% after the merger. Thus, the majority of acquiring firms are in the top quartile, and the cost advantage of the majority of acquiring firms increases after the merger.

In contrast, about 14% of acquiring firms rank among the 20% least-efficient unmerged firms before the merger. After the merger, about 17% of acquiring firms rank among the 20% least-efficient unmerged firms. Thus, some acquiring firms do not achieve cost savings.

The dispersion in merger outcomes is also reflected in industry reports. One possibly unsuccessful merger was that of Champion International Corp. and St. Regis Corp. The merger did not achieve the expected cost synergies and eventually resulted in a downsizing of the merged company.[18]

Acquired firms also tend to be relatively efficient. About a quarter of the acquired firms have a marginal-cost estimate among the most efficient decile of unmerged firms. About half of the acquired firms are among the top quartile of unmerged firms.

In summary, acquiring firms on average have lower marginal cost, both before and after the merger. For the majority of acquiring firms, the cost advantage increases after the acquisition. However, some acquiring firms do not achieve cost savings.

□ **Welfare effects.** I now take the analysis one step further and quantify welfare effects. The estimated cost parameters of individual firms can be used to predict the investment behavior of firms under the industry configuration in which mergers are prohibited. The predicted "no-merger" equilibrium can be employed to determine the changes in consumer and producer surplus due to merger.

The calculation of producer surplus requires firm-specific cost functions. I assume that the technology is characterized by the marginal-cost function described in equation (7) and there are no fixed costs. To the extent that there may be savings in fixed costs due to mergers, my estimates will understate the benefits of mergers for producer surplus.

Welfare effects are calculated using the capacity data, the estimated marginal cost, and the demand estimates. Specifically, the marginal cost and capacity of the merged firm are replaced

[18] See *Business Week,* February 25, 1985, p. 68.

by the marginal cost and capacity of the individual components prior to the merger wave. The equilibrium reaction functions, which are implicitly given in (2) in Section 3, are used to numerically calculate the investment equilibrium in the no-merger industry configuration. A comparison between the merger and no-merger equilibrium investment decision enables me to calculate changes in consumer and producer surplus based on equations (4) and (5) in Section 3.

The first-stage inverse-demand elasticity estimates and the assumed decay parameter and cost of additional capacity affect firms' marginal-cost estimates asymmetrically. Thus, the welfare estimates will depend on the accuracy of these estimates. The remaining demand parameter estimates, the constant and the coefficient associated with GDP, affect firms' marginal-cost estimates symmetrically and will not alter the qualitative properties of the welfare estimates. I take the accuracy of the first-stage inverse-demand elasticity estimates into account by randomly drawing inverse-demand elasticity parameters from a normal distribution with mean equal to the estimated inverse-demand elasticity and variance equal to the estimated variance. For each draw, I estimate a marginal-cost function and take the accuracy of the second-stage cost estimates into account by randomly drawing from a normal distribution with mean equal to the estimated cost parameter vector and covariance matrix equal to the estimated covariance matrix. I repeat the welfare calculation 100 times and report the sample average and sample standard deviations of the calculations. I assume the baseline specification of capacity cost $r(x)(1-\beta)/\beta = 26.5x + .005x^2$ and a decay parameter $\delta = .999$. I conducted a robustness analysis of the welfare estimates varying the cost of investment and the decay parameter.

Table 7 summarizes the estimates. Estimation results are reported for individual paper categories. Five variables are reported for every product category: CONSUMER SURPLUS measures the annual change in consumer surplus due to the merger based on equation (4). PRODUCER SURPLUS measures the annual change in producer surplus based on equation (5). TOTAL WELFARE measures the change in the sum of producer and consumer surplus. GAIN TO MERGED FIRMS measures the change in annual profitability of the merging firms. GAIN TO UNMERGED FIRMS measures the effect on profits of unmerged firms. All dollar amounts in Table 7 are measured in thousand 1986 dollars.

The estimates indicate the following effects for packaging papers: The first element in Table 7 suggests that the mergers increased the annual total welfare by $47.6 million. The number in parentheses gives the standard deviation, $27.9 million, which indicates that the welfare increase is marginally significant. The welfare effect stems from an increase in producer surplus of $264.8 million while consumer surplus decreased by $217.2 million.

Total welfare effects are positive for seven of eight products. They are significant across all specifications for four out of eight categories: coated papers, uncoated papers, tissue,

**TABLE 7 Welfare Effects (in $000)**

| | Product Category | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Packaging Paper | Groundwood Printing | Coated Papers | Uncoated Papers | Other Papers | Tissue | Boxboard | Linerboard |
| TOTAL WELFARE | 47,636 | 5,729 | 20,199 | 69,673 | 86,899 | 321,689 | −34,408 | 373,804 |
| | (27,886) | (14,113) | (5,336) | (31,767) | (99,551) | (94,813) | (178,665) | (180,893) |
| CONSUMER SURPLUS | −217,182 | −1,592 | −37,234 | −173,589 | −15,298 | 76,328 | 494,805 | 476,544 |
| | (218,470) | (20,086) | (72,315) | (294,250) | (255,025) | (65,627) | (1,032,992) | (1,150,344) |
| PRODUCER SURPLUS | 264,818 | 7,321 | 57,433 | 243,261 | 102,197 | 245,362 | −529,213 | −102,740 |
| | (202,776) | (27,363) | (75,359) | (304,369) | (346,787) | (102,698) | (1,062,749) | (1,198,163) |
| GAIN TO MERGED FIRMS | 177,619 | 10,399 | 33,230 | 101,871 | 52,960 | 269,148 | −259,671 | 43,313 |
| | (132,885) | (11,962) | (28,612) | (108,147) | (104,846) | (88,871) | (532,635) | (698,009) |
| GAIN TO UNMERGED FIRMS | 87,199 | −3,078 | 24,203 | 141,390 | 49,236 | −23,786 | −269,542 | −146,053 |
| | (73,165) | (17,895) | (47,565) | (203,025) | (247,581) | (39,525) | (564,225) | (517,768) |

Standard errors in parentheses.

and linerboard. For packaging papers, groundwood printing, and other papers the welfare estimates are positive but not significant. Welfare effects for boxboard are negative.

Consumer surplus estimates are negative in five of eight categories. Consumer surplus estimates are not significantly different from zero for any product category. Producer surplus estimates are positive for six of eight categories. For boxboard and linerboard the producer surplus estimates are negative. Producer surplus estimates are significant only for tissue.

I also considered different specifications for the decay parameter and the cost of additional capacity. Lowering the decay parameter to $\delta = .95$ yields results similar to those in Table 7, which suggests that altering decay does not affect the results substantially. Varying the cost of additional capacity also yields qualitatively similar estimates as the baseline specification for most product categories.

Calculating the sum of welfare effects across product categories reveals that the merger wave increased total welfare in the paper industry by $891.2 million per year. The total benefit to consumers amounts to $602.8 million. The sum of producer surplus increased by $288.4 million.

□ **Profitability of mergers.** This subsection examines the profitability of mergers. I report estimates based on two measures: First, I report estimates of the merger effects on firm profit based on the model estimates. Second, I contrast the estimates with stock market evidence on the shareholder wealth of publicly traded paper companies. The comparison may provide an assessment of the quality of the estimates.

In the estimation of cost parameters, I did not impose the constraint that mergers are profitable. However, it may be argued that this condition must be satisfied at least for the average acquisition.[19] Instead of imposing this condition as a constraint in the estimation, I determine to what extent it is satisfied by my estimates. This may be interpreted as a test of the adequacy of the investment model.

The profitability of the average merger and acquisition can be calculated based on the model estimates. Table 7 reports the gains to merged firms and the gains to unmerged firms for individual product categories. The merger gains are positive in all categories except boxboard. For tissue they are significant.

The gains to unmerged firms are negative in four of eight cases but are not significant for any product category.

Summing across product categories reveals that the merged firms achieved profit increases. The total gain amounts to $428.8 million per year. Unmerged firms achieved a loss of $140.4 million per year.

In four mergers, both the acquiring and the acquired firms are publicly traded.[20] Following the literature on the effect of mergers on shareholder wealth, I measure changes to the shareholder wealth around the merger announcement date. I consider a two-week event window, starting one week before and ending one week after the announcement date. The combined value of the companies in the four mergers increases, with a total gain of $906.6 million. News about merger talks may become public a number of months prior to the announcement date, as was the case for the merger between International Paper and Hammermill.[21] To take earlier news into account, I also measure changes in shareholder wealth beginning six months before and ending one week after the announcement date. The total gain amounts to $1,224.0 million. This amounts to a relative increase of 20.2%; as a comparison, the S&P 500 index increased by 5.0% during the same period.

[19] The profitability of a merger may depend on the rules of the merger game. I assume that firms take future (or simultaneous) mergers into account when they assess whether to undertake an acquisition. Thus, I compare the profits before and after the merger wave.

[20] These mergers are the following: Champion and St. Regis; Stone Container and Southwest Forest; James River and Crown Zellerbach; and International Paper and Hammermill.

[21] Two bidders were engaged in a bidding war over a number of months. An examination of the stock market price reveals that during the bidding period, the value of Hammermill increased steadily.

In sum, I find that both the estimated gains based on the investment model and the stock market responses are positive. This finding can be interpreted as a confirmation of the model's predictions. Due to measurement error in the stock market data and the fact that only four mergers involve publicly traded companies, a direct comparison between the predicted profitability and the stock market evidence has to be interpreted with caution. However, imposing an annual interest rate of 5%, the future discounted gains predicted by the investment model equal \$9.01 billion for 31 mergers. The change in the stock market value in the event window ranges between \$.90 billion and \$2.54 billion. Since the stock market evidence accounts for only four of the 31 mergers, the two numbers appear comparable.

## 7. Conclusions

■ I have focused on investment decisions rather than short-run changes in price or output. Investment decisions reflect the long-run considerations and seem more appropriate to use to assess merger welfare implications. A one-shot investment game is considered and taken to the data. The estimation method is based on the first-order condition of optimal investments. The method consists of two stages. In the first stage, the demand parameters are estimated assuming homogeneous products within a product category. In the second stage, firm-specific marginal production costs are estimated. The demand and marginal-cost estimates are used to assess the welfare effects of a merger wave that took place during the mid-1980s. It is shown that merging firms achieve cost savings relative to their stand-alone constituent parts. Welfare effects are mostly positive, due to the increased producer surplus. The consumer surplus is not affected significantly by the mergers.

There are at least two shortcomings of the analysis: First, the marginal-cost estimates rely on the specification of investment model. In future research it may be worthwhile to contrast the cost estimates to actual cost data for an industry where cost data are available. Second, I take merger decisions as exogenous and verify *ex post* whether merger decisions were indeed profitable. My assumption stems from the lack of a convincing merger model. However, endogenizing merger decisions may place additional restrictions on the data that help to estimate firms' costs.

### Appendix A

■ Proofs of Remarks 1–4 follow.

*Proof of Remark 1.* I begin with the situation prior to the merger. The payoff function for firm $i$ is $[A - bQ]q - cq$. The first-order condition of profit maximization yields $A - bQ - bq - c = 0$. Summing over all firms yields an expression for total industry production, $Q = n(A - c)/b(n + 1)$. Thus, Cournot capacities equal $(A - c)/b(n + 1)$. Substituting equilibrium capacities into the payoff function yields that Cournot profits equal $[A - b[n(A-c)/b(n+1)]] \cdot [(A-c)/b(n+1)] - c[(A - c)/b(n + 1)]$, which can be rewritten as $(1/b)[(A - c)/(n + 1)]^2$. A merger is profitable if the postmerger profit exceeds twice this expression.

Next, I consider the postmerger situation. Let $m$ denote the index for the merged firm and $i$ the index for an unmerged firm. The first-order condition for nonzero investments by an unmerged firm is given by

$$A - c - b[\sum K_j + \sum x_j + K_i + x_i] = r \cdot 1_{\{x_i > 0\}}.$$

Substituting Cournot capacity levels yields

$$A - c - b[\frac{n}{n+1}\frac{(A-c)}{b} + \sum x_j + \frac{A-c}{b(n+1)} + x_i] = r \cdot 1_{\{x_i > 0\}}.$$

Cancelling terms yields

$$-b[(n-1)x_i + x_m] = r \cdot 1_{\{x_i > 0\}}.$$

An examination of the Kuhn-Tucker conditions yields three distinguishable cases: First, if $x_m < -r/b$, then $x_i > 0$. Second, if $x_m \in [-r/b, 0]$, then $x_i = 0$. Third, if $x_m > 0$, then $x_i < 0$.

Consider next the merged firm $m$. The first-order condition for nonzero investments for the merged firm is given by

$$A - c - b\left[\sum K_j + \sum x_j + K_m + x_m\right] = r \cdot 1_{\{x_m > 0\}}.$$

Substituting Cournot capacity levels yields

$$A - c - b\left[\frac{n}{b(n+1)}(A-c) + \sum x_j + 2\frac{A-c}{b(n+1)} + x_m\right] = r \cdot 1_{\{x_m > 0\}}.$$

Rearranging terms yields

$$-\frac{A-c}{n+1} - b[(n-2)x_i + 2x_m] = r \cdot 1_{\{x_m > 0\}}.$$

Suppose that $x_i = 0$. Then the first-order condition for firm $m$ yields $x_m = -(1/2b) \cdot (A-c)/(n+1)$. Observe that these investment decisions constitute an equilibrium provided the condition stated in the remark is satisfied. To see this, notice that the first-order condition for firm $i$ implies that $x_i$ is indeed zero, provided that $x_m > -r/b$. This condition can be rewritten as $(A-c)/[2(n+1)] < r$, which is the condition stated in the remark.

Finally, I substitute equilibrium investment levels into payoffs to assess the profitability of the merger: The profit for firm $m$ is given by $[A - c - [b(2n-1)/2b(n+1)](A-c)] \cdot (3/2b)(A-c)/(n+1)$. Simplifying this expression yields $(1/b)[(A-c)/(n+1)]^2 \cdot (9/4)$. The merger gains are given by the difference between the postmerger equilibrium profit and the premerger profit. This yields $(1/b)[(A-c)/(n+1)]^2 \cdot (1/4)$, which is indeed positive. *Q.E.D.*

*Proof of Remark 2.* Consider the equilibrium investment condition for the merged firm after the merger. Let $c_m$ denote the marginal cost of the merged firm. From Proposition 1, it is given by

$$x_m \cdot \left[A - c_m - b\left(\sum K_j + \sum x_j + K_m + x_m\right) = r \cdot 1_{\{x_m > 0\}}\right] = 0.$$

By assumption, there is no investment, $x_i = 0$ for all $i$, and capacities equal Cournot levels. The Kuhn-Tucker condition implies that

$$A - c_m - b\left[\frac{n(A-c)}{b(n+1)} + 2\frac{A-c}{b(n+1)}\right] \geq 0.$$

This can be rewritten as

$$A - c_m - \frac{n+2}{n+1}(A-c) \geq 0,$$

which gives the inequality $(A - c_m)/(A-c) \geq (n+2)/(n+1)$. The inequality implies that the marginal cost after the merger is below the level prior to the merger, $c_m < c$. *Q.E.D.*

*Proof of Remark 3.* Observe that production costs are unaffected by merger, since all firms have the same marginal cost. Thus, it is enough to establish that consumer surplus declines. Suppose to the contrary, that is, that capacity increases after the merger, $\sum x_j > 0$. Now, the first-order condition for firm $i$ implies that $x_i \leq 0$. Consider next the first-order condition for firm $m$. It implies that $x_m \leq 0$. But $\sum x_j = (n-2)x_i + x_m$, which yields a contradiction. Thus, capacity declines after the merger. *Q.E.D.*

*Proof of Remark 4.* Observe that consumer surplus is unaffected by a merger, since aggregate output does not change. Remark 2 states that the marginal cost of the merged firm declines. Therefore, producer surplus increases, yielding an increase in total welfare. *Q.E.D.*

## Appendix B

**TABLE B1 Timing and Price of Acquisitions Between August 1, 1984, and July 17, 1987**

| Announcement Date[a] | Price | Description of Acquisition |
|---|---|---|
| 8/1/1984 | $1.8 bil | Champion International Corp. acquires St. Regis Corp. |
| 8/8/1984 | N/A | Little Rapids Corp. acquires Potsdam Paper Corp. |
| 9/11/1984 | N/A | Simpkins Industries Inc. acquires Deerfield Speciality Papers |
| 11/5/1984 | N/A | International Paper acquires Durham Mills Inc. |
| 1984 | $382 mil | USGA Acoustical Products Co. acquires Masonite Corp. |
| 1984 | N/A | Caraustar Industries acquires Mobil Corp. |
| 1984 | N/A | Simpson Paper acquires Harding Jones Paper Corp. |
| 3/6/1985 | $260 mil | Federal Paper Board Co. acquires Continental Forest |
| 4/29/1985 | N/A | Hammermill Paper Business acquires Nicolet Paper Co. (owned by Philip Morris Industrial Inc.) |
| 5/1/1985 | $214 mil | Chesapeake Paper Products Co. acquires two units of Philip Morris Industrial (Tissue Mill Inc. and Plainwell Paper Co.) |
| 7/1/1985 | $75 mil | Simpson paper acquires a division of Champion International Corp. |
| 8/12/1985 | $40 mil | USG Acoustical Prod. Co. acquires Conwed Corp. |
| 9/30/1985 | $442 mil | Stone Container acquires a division of Champion International (division sold after merger with St Regis Corp.) |
| 12/6/1985 | $150 mil | Jefferson Smurfit Corp. acquires a division of Publisher Paper Co. (owned by Times Mirror) |
| 12/17/1985 | $800 mil | James River acquires Crown Zellerbach |
| 12/21/1985 | N/A | Federal Paper Board Co. acquires divison of Nabisco Inc. |
| 1985 | N/A | Packaging Corp. of America acquires Diamond Int. Corp. |
| 1/3/1986 | N/A | James River Corp. acquires a division of Preco Corp. |
| 2/4/1986 | $228 mil | Temple Inland acquires a division of Owens Illinois Inc. |
| 7/27/1986 | $1.2 bil | Jefferson Smurfit Corp. acquires Container Corp. (owned by Mobil Corp.) |
| 8/12/1986 | $1.1 bil | International Paper acquires Hammermill |
| 8/21/1986 | N/A | Stone Container acquires a divsion of Newark Group |
| 12/31/1986 | N/A | Stone Container acquires Jackson Ville Kraft Paper Co. |
| 12/23/1986 | N/A | Georgia-Pacific acquires Superwood Corp. |
| 1986 | N/A | Boise Cascade Corp. acquires SCM Corp. |
| 1986 | N/A | Jefferson Smurfit Corp. acquires a division of Union Camp Corp. |
| 1/28/1987 | $442 mil | Stone Container acquires Southwest Forest |
| 2/2/1987 | $24 mil | Pope & Talbot acquires a division of Potlach Corp. |
| 2/3/1987 | N/A | Jim Walter Corp. acquires Owens Corning Fiberglass Corp. |
| 3/26/1987 | N/A | James River acquires Dennison Mfg. Co. |
| 7/17/1987 | $1.15 bil | Great Northern Nekoosa acquires Owens Illinois |

[a] The date is the announcement date of the merger. I report only the announcement year when the exact announcement date is not known.

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