Industry Consolidation and Price-Cost Margins

--Evidence from the Pulp and Paper Industry

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Abstract

In recent years, the U.S. pulp and paper industry has experienced an increasing degree of consolidation through a series of mergers and acquisitions. Based upon a structure-conduct-performance model and using panel data for the pulp, paper, and paperboard sectors from 1970 to 1997, this paper investigates the effect of industry structure on price-cost margins. Unlike previous studies, which rely on an interpolated concentration measure calculated from output values, this study uses a measure of concentration based upon annual productive capacity, which significantly reduces measurement errors and endogeneity concerns. Results from the analysis indicate that one percent increase in market concentration increases price-cost margins by 0.5 to 0.6 percentage points. The effect, however, fluctuates with business cycle and displays a pro-cyclical pattern. Additional results indicate that import competition reduces operating profits of the domestic industry whereas expenditures on meeting government mandated environmental regulations has a positive effect on the industry's price-cost margin, suggesting that industry is shifting at least part of the cost of these regulations to its customers.

Key Words: Price-Cost Margin, Market Concentration, Pulp and Paper Industry

I. Introduction

In recent years, the U.S. pulp and paper industry has undergone a series of mergers and acquisitions which, collectively, have consolidated the pulp, paper, and paperboard sectors of the industry. Not surprisingly, this has increased market concentration considerably. Between 1972 and 1997 and based on the Census of Manufacturers (U.S. Bureau of the Census), market concentration, defined as the share of the top four producers (CR4) for the paper and paperboard sectors rose from 24% to 33.6% and from 29% to 33.6%, respectively. In the pulp sector, market concentration rose steadily from 44% in 1987 to 58.6% in 1997. Beyond 1997, the concentration in all three sectors increased further, especially in paperboard, with the CR4 climbing to 45%.

A natural question is whether industry consolidation increased firms' abilities to generate operating profits. Industry consolidation is expected to improve efficiency by reducing production costs through greater economies of scale, as well as by technological innovations through larger R&D investments.[1] Demsetz (1974) suggests that the largest producers are superior in producing and marketing their products, which enables these firms to earn above-normal profits. Peltzman (1977) finds that returns to innovative activities generate a positive relationship between profits and concentration and Salinger (1990) finds that high levels of concentration are associated with price and cost decreases. In addition, consolidation may improve the ability to support prices. Based on Werden (1991), 72.8 % of the studies reviewed by Weiss (1989) showed a positive and significant relationship between market concentration and prices.

[1] An alternative to the 'efficiency hypothesis' is a 'collusion hypothesis' wherein firms are also more likely to collude as concentration increases, which leads to higher expected operating margins.

The primary objective in this analysis is to use the structure-conduct-performance (S-C-P) model in order to empirically estimate the effect that industry consolidation has had upon operating profit rates for an important segment of the forest products industry, namely, the pulp and paper (including paperboard) industry. Much of the literature on industry structure and performance focuses upon the S-C-P paradigm, which identifies the effect of industry structure – variously defined by the number of firms, measures of concentration and entry barriers – on performance, as reflected in market power and allocative efficiency, technological progress, and profits. The traditional approach uses cross-sectional data to estimate the structure-performance relationship. Weiss (1974) reviewed early studies of this relationship and more recent studies include those of Domowitz, Hubbard, and Petersen (DHP) (1986a, 1986b) and Salinger (1990).[2]

This study contributes to the existing literature in several ways. First, in contrast to most studies that use market concentration measures based upon actual production, this study bases its measure of concentration upon productive capacity. Given the long-term nature of investment in the pulp and paper industry, productive capacity in a capital intensive industry is much less likely to be correlated with the unobserved factors that affect the current profit margins, which reduces endogeneity concerns for capacity-based concentration measures relative to output- or sales-based measures (Froeb and Werden, 1991).

[2] Historically, the vast majority of studies test the S-C-P model using inter-industry data, that is, data on a large number of different industries (e.g. DHP, 1986b). Since industry structure is heterogeneous across industries, inter-industry analyses will have more difficulty identifying the relationship between structure and performance embodied in the S-C-P model because of measurement problems associated with market definition and concentration (Salinger (1990)). While a large number of industries increases the sample size, an implicit assumption is that industry concentration imposes a common effect on profit margins across a heterogeneous set of industries. Additionally, in many cases, industrial classifications may not measure economically meaningful markets. Bresnahan (1989) reviews research that has used data on specific or closely related industries.

Second, many structure-performance studies employ Census data, which are reported every five years, and interpolate concentration measures for the missing years.[3] Since the interpolated measures are likely to differ from their true values, the data series are measured with error which leads to attenuation bias in a regression.[4]

By employing concentration measures based upon annual productive capacity, it is expected that this study will identify a more reliable structure-performance relationship than studies based upon quinquennial data and output-based measures of concentration. A further contribution of this study is its focus upon the pulp and paper industry. In contrast to other industries, including airline, banking, advertising, and gasoline and grocery retailers and cement (Weiss 1989, Schmalensee 1989, and Werden 1991, and Koller and Weiss 1989) and notwithstanding that there has been an active pattern of consolidation in the industry, to our knowledge, there is no existing study that examines the effect of industry consolidation on price or price-cost margins.

Section II discusses the characteristics and changes in the U.S. pulp and paper industry. Section III discusses the structure-conduct-performance model and the empirical specification. Data and empirical results are discussed in Sections IV and V, and Section VI concludes.

II. The US Pulp and Paper Industry

The pulp and paper industry in the United States is a large, capital intensive, traditional industry. Annual capital investments are in the $8 - $15 billion range, where a

[3] Every five years, the U.S. Bureau of Census conducts a Census of Manufacturers and publishes shipment-based CR4s for all industries classified according to the Standard Industrial Classification (SIC) system.
[4] Attenuation bias reflects a weaker estimated relationship between an explanatory variable and the dependent variable and occurs when an explanatory variable is measured with imprecision.

modern pulp and paper mill capable of producing 300,000 – 500,000 tons per year represents an investment of hundreds of millions of dollars and a planning cycle from idea to actual mill startup varying between 3 – 10 years. Productive capacity in the industry has significantly increased over the past 20 years – from 70.1 million short tons (msts) in 1982 to 100.5 msts in 2002, after peaking in 2000 at 103.9 msts.[5] New supply, defined as new production plus net imports, increased from 64.2 million to 98.9 million short tons during the same period, representing a 2.6% annual increase. On a per capita basis, new supply increased from 557.6 pounds in 1982 to 687.6 in 2002 (a 23.3% rise) after peaking in 1999 at 754.2 pounds per capita. And new supplies of paper and paperboard output accounted for 10.4% of real GDP (1996 chained dollars).[6] In 1998, employment in paper and allied industries represented 4% of the total U.S. manufacturing sector and the forest products industry, of which the pulp and paper industry accounts for 40%, is among the top ten employers in 43 out of 50 states.[7]

Worldwide, the industry produces more than 300 million tons of product which generates annual revenues of over $500 billion[8]. The US industry accounts for about a third of worldwide output. Imports of pulp and paper from outside the US totaled 27.1 million tons which is a bit more than the 26.2 million tons exported in 2002. In the pulp and paper industry, the pulp sector has the highest level of imports, accounting, on

[5] American Forest & Paper Association, *Statistics of Paper, Paperboard and Wood Pulp, 1979-1999*; American Forest & Paper Association, *2003 Statistics*.
[6] American Forest & Paper Association, *2003 Statistics*.
[7] "Paper and Allied Products," *U.S. Industry & Trade Outlook '99*. McGraw-Hill: New York, 1999, 10-2.
[8] "Profits Leap Ahead in '99," *Paper and Forest Products Industry Survey*, Standard & Poor's, New York, Apr. 13, 2000, p. 1.

average, for approximately 35% of the total sales in the U.S.[9] Conversely, the paperboard sector has the lowest import penetration, reflecting approximately 1% of the total sales. The paper sector has imports that represent roughly 15% of the total sales. And the pattern of imports over years has been very stable for each sector, with only the pulp sector showing some degree of volatility.

Similar to other capital intensive industries, the pulp and paper industry must meet a number of federal environmental regulations. There are three main laws regulating environmental impact of the pulp and paper industry's productive activities. The Clean Air Act (Air Quality Act of 1967, CAA) requires pulp and paper companies to install the best available technology to preserve the quality of air resources. The Clean Water Act (Federal Water Pollution Control Act Amendments of 1972, CWA) requires mills to control and limit the amounts of pollutants discharged in the nation's waters. The Resource Conservation and Recovery Act of 1976, which supplants the original Solid Waste Disposal Act, encourages pulp and paper mills to phase-out production of persistent or bioaccumulative toxic substances and to replace these substances with safer alternatives. In addition, the Cluster Rule, finalized in 1997, is designed to put together Water and Air regulations and provide for a consistent, non-exclusionary body of rules. The Environmental Protection Agency estimates that the cumulative effect of the environmental regulations has cost the industry about $1.8 billion.[10]

[9] Market pulp comprises only about 15 percent of total U.S. pulp production because of integrated mills. Most of pulp imported comes from Canada. According to the North American Fact Book on Pulp and Paper, in 1998 over 5 million tons were imported to the U.S., 87 percent of which came from Canada. The rest of the imports came from Brazil, Chile, Finland, New Zealand, Portugal, Spain and Sweden.

[10] The American Forest and Paper Association (AFPA) estimates that the costs are closer to $2.6 billion, plus annual operating costs of $273 million.

Notwithstanding continuing growth in the pulp and paper industry, its economic and financial performance has been less than impressive. The industry's lackluster return on investment during the past two decades is at least partially due to its large investments in productive capacity during the 1980's, a period of rising prices, which, when combined with subsequent capacity increases in Europe, Asia, and South America, have resulted in a persistent over-capacity.[11]

In hopes of more effectively managing industry capacity, lowering unit costs of production, stemming price declines, and improving operating profits and returns on investment, pulp and paper firms shifted to consolidation strategies – mergers and acquisitions. Industry consolidation has been on the rise since the 1980's and continued throughout the 1990s. The pace of change, measured by the number of mergers per year, picked up in the late 1990's.[12] From 1970 to 1979, the average annual number of mergers in the pulp, paper, and paperboard sectors was 4; from 1980 to 1989, this increased to 7. And during the 1990s, there averaged 9 mergers per year. The most active merger activity was observed in the paperboard industry, with a record 35 mergers in 1998. In 2000, the pulp and paperboard sector each has 6 mergers; while the paper sector underwent 24 mergers.

As a result of accelerated consolidation, it is natural to expect that market concentration has risen and this has indeed occurred. Based on Census data, the market share of the top four producers in the paper sector rose from a low of 20% in 1970 to

[11] State of the North-American (and Maine) Pulp and Paper Industry—An Update and Outlook," Center for Paper Business and Industry Studies, 2003, http://www.paperstudies.org/industry/030403_State_of_the_Industry_Maine.pdf.

[12] Annual mergers by sector were calculated using database provided by the Forrest Products Laboratory (FPL). The FPL data are described in the subsequent sections.

30% in 1997; in the paperboard sector, the market share nearly doubled, rising from 20% to about 35%; and for the pulp sector, after a decline of market concentration from 1972 through middle 1980s, market concentration steadily increased from 40% to approximately 60%.[13]

Whether industry consolidation has had its desired effects upon efficiency, price, and profitability is yet not clear. Industry analysts believe that the latest consolidation has helped to support the price.[14] However, in a recent study, Li and Luo (2004) present evidence that consolidation in the paperboard sector of the industry has not had a significant effect on prices.

Nevertheless, price-cost margins (PCMs) in the pulp and paper industry have modestly increased. Measured by 10-year averages, the price-cost margin in the pulp sector averaged 31% in 1970s, slightly increased to 32% in the 1980s, and rose to 34% in 1990s. Changes in paper and paperboard PCMs are more dramatic – averaging 25%, 30%, and 34% in the paper sector and 28%, 32%, and 36% in the paperboard sector.[15] Interestingly, despite the rising price-cost margins, paper and allied industry profit rates (i.e. net profits after taxes as a proportion of net worth) remained at a 10% average during 1970-1997[16].

[13] The absolute overall level of market concentration in the pulp and paper industry is still relatively low. Based on Salinger (1990, p.288), in 1969 the "so-called Neal report" recommended an active policy of "deconcentration" based on evidence of 15 percent of market share held by one firm and a 70 percent by four top firms.

[14] Louis Uchitelle, "Who's Afraid Now That Big Is No Longer Bad?" New York Times, November 5, 2000. The article states: "Linerboard has risen in price to $475 a ton, from $340 in 1998. That is still below the peak of $525 in 1995, but the mergers and the reduction in excess capacity have stabilized prices."

[15] Bureau of the Census, Annual Survey of Manufacturers, various years.

[16] AFPA Annual Review Report (1998).

III. Methodology and Empirical Specification

IIIa. Structure-Conduct-Performance Framework

The traditional S-C-P model argues that there is a causal link between industrial structure (S) and industry performance (P), both directly and mediated through conduct (C) or industry behavior. According to this framework,

(1) $P = g(S, C(S), \text{other factors})$

The number and size distribution of firms in an industry, industry concentration, and entry or exit barriers define an industry's structure and this directly influences its ability to earn profits, allocate resources efficiently, and innovate. An industry's structure also affects its behavior or conduct in providing incumbent firms with incentives to strategically pursue actions that materially affect their performances, for example, by differentially pricing or advertising depending upon industry concentration or the size distribution of firms.

Since, as noted in (1), there is an assumed link between industry conduct and structure, the S-C-P model collapses to a structure-performance (S-P) model, summarized in the expression

(2) $P = h(S, \text{other factors}).$

It is important to note that the traditional S-P approach assumes that causality runs from industry structure to performance. However, it is also likely that industry performance has a feedback effect upon structure. Innovation in a particular firm, for example, may reap significant profits for the firm which enables it to increase its market share substantially, thereby altering the number or size distribution of firms. It is important in

the analysis that follows, therefore, to test for reverse causality in order to isolate the impact that industry structure has upon performance.

As suggested above, there are various ways to measure industry structure and performance. Following the literature, this analysis uses the four-firm concentration ratio, CR4, as a measure of pulp and paper industry structure. The Lerner index L, defined as

$$(3) \qquad L = \frac{p - MC}{p}$$

where p is price and MC is marginal cost, is a desired measure for industry performance because it targets an industry's market power, i.e. the ability to price above marginal cost. Unfortunately, marginal costs are rarely, if ever, available, which requires an approximate measure based upon available data. This analysis uses the operating profit rate of return on sales (Salinger 1990) to measure industry performance. In particular, assume that all firms in an industry produce a homogeneous output q. Then, for the industry

$$(4) \qquad \text{Operating Profit Rate of Return on Sales} = \frac{TR - TVC}{TR} = \frac{(p - AVC)q}{p \cdot q}$$

where TR is total revenues and TVC (AVC) is total (average) variable cost. Further, for constant marginal costs, average variable cost equals marginal cost so that (4) can be expressed as

$$(5) \qquad \text{Operating Profit Rate of Return on Sales} = \frac{(p - AVC)q}{p \cdot q} = \frac{p - MC}{p} = L$$

In other words, the average profit rate equals the Lerner index for a homogeneous good produced under constant costs and approximates the index to the extent that output is heterogeneous and costs are not constant. For capital intensive industries with high fixed costs and high operating ratios, it is reasonable to assume that operating costs are

relatively constant. In addition, it is often argued that pulp and paper is a commoditized industry, suggesting that the pulp, paper, and paperboard segments approximate a homogeneous product.[17]

The S-P model to be tested in this paper is

$$(6) \qquad \frac{(p - AVC)}{p} = h(CR4, \text{other factors})$$

where the null hypothesis is that an increase in concentration, by increasing market power, is expected to increase the average profit rate of the industry. A positive relationship should provide at least a tentative indication of whether an industry operates in an oligopolistic market. [18]

IIIb. Empirical Specification

To operationalize the S-P model in (6), it is necessary to obtain a measure of the industry's average profit rate and the four-firm concentration ratio. This analysis follows the approaches of Collins and Preston (1966, 1969), Shepherd (1972), and DHP (1986a, 1986b) with the industry price-cost margin (PCM), defined as

$$PCM = \frac{\text{Value Added} - \text{Labor Costs}}{\text{Value of Shipments}}$$

where Value Added is the value of shipments minus materials costs (Census of Manufacturers). Labor costs and the cost of materials are the actual expenditures in the

[17] Two segments in the paper sector, fine writing papers and tissue, are consumer oriented products and more heterogeneous than other paper and paperboard segments.

[18] There are potentially two rationales for a positive association between concentration (i.e. structure) and the price-cost margin (i.e. performance). A 'collusion' hypothesis argues that increased concentration facilitates collusive behavior which leads to market power and increased profits. Alternatively, the efficiency hypothesis argues that superior firm performance, through decreases in costs, enables a firm to increase its market share and market power, thereby raising profits.

calendar year. The value of annual shipments may differ from the value of output because of changes in inventories. To avoid the "inventory bias", the PCM is adjusted for annual inventory changes so that, for this analysis, PCM is defined as

$$(7) \qquad PCM = \frac{\text{Value of Shipments} - \text{Materials Costs} - \text{Labor Costs} + \Delta\text{Inventories}}{\text{Value of Shipments} + \Delta\text{Inventories}}$$

Note that the PCM in (7) is a proxy for operating or short run profits since it does not account for fixed or sunk costs.[19]

The four-firm concentration ratio, CR4 FPL, for this study is based upon productive capacity in the industry rather than upon shipments. Froeb and Werden (1991) argue that production-based measures of concentration (e.g. sales or shipments), which are often the only data available, more appropriately reflect performance rather than industry structure. Capacity-based measures of concentration, which are often unavailable, are better measures of industry structure. In addition, capacity-based measures of concentration significantly reduce concerns about endogeneity and simultaneity bias associated with production-based measures.

The empirical specification of the S-P relationship in this paper is

$$(8) \qquad PCM_{jt} = \beta_0 + \beta_1 \, CR4\_FPL_{jt} + \gamma' x_{jt} + \varepsilon_{jt} \qquad j = \text{pulp, paper, paperboard; } t = \text{year}$$

where PCM_{jt} is the price-cost margin for industry sector j and year t, $CR4\_FPL_{jt}$ is the four-firm concentration ratio in sector j and year t, β_i (i = 0, 1) is a parameter, γ is a parameter vector associated with a vector x_{jt} of other explanatory variables influencing the price-cost margin, and ε_{jt} is an error term.

[19] The PCM also excludes such variable costs as general and administrative, advertising, and tax expenses.

A number of studies, including Ghosal (2000), Katics and Petersen (1994), Pugel (1980), and Caves (1985), support the hypothesis that imports have had an increasing influence on industrial price-cost margins, and that such influences tend to be stronger in more concentrated industries. This literature treats import intensity, defined to be imports as proportion of total industry sales, in either of two ways.[20] First, the model includes import intensity as an independent variable. Second, the model defines an 'adjusted' CR4 which accounts for the volume imported products and is defined as:

Adjusted CR4_FPL = CR4_FPL * Import Intensity.

Because domestic shipments enter the definition of the price-cost margin and total sales, including import intensity in the estimating equation may lead to endogeneity problems (Salinger (1990)). To address this problem, the estimated equations reported in this analysis use a one-year lagged term for import intensity.[21]

Three other variables are potentially important for this analysis. As discussed in the previous section, environmental regulations have had a profound effect on the paper and pulp industry because these regulations have required the industry to invest an annual average of 10.82% of total capital spending in pollution abatement technologies in order to meet various environmental standards.[22] *Environmental Expenditure,* defined as total capital expenditures for environmental purposes in the pulp and paper industry, have wide variations over the period of study, but with particularly steep increases in the years the legislation was passed as well as in the years immediately following enactment of the

[20] Let I be annual imports and S be domestic sales, and TS equal total sales. Then import intensity is I/(I+S) = I/TS.
[21] Data on imports are available in the annual compilation of Statistics of Paper, Paperboard and Woodpulp, published by the AFPA.
[22] North-American Pulp and Paper Factbook.

regulation. For example, in 1972 when the Clean Water Act was passed, the environmental expenditures increased 62% while the average annual increase for 1971-75 period was only 20%. It is expected that firms will attempt to shift the burden of these environmental regulatory costs onto consumers in the form of higher prices, which will affect the industry's performance. To investigate this, the empirical model includes capital expenditures on environmental abatement technologies as an additional explanatory variable.

Second, capital intensity is usually included in structure-performance models to capture the difference between capital-intensive and non-capital intensive industries. However, since pulp, paper, and paperboard mills all have similar, highly intensive, capital requirements, it is not necessary to include capital intensity in our empirical models. Third, advertising intensity to reflect conduct or behavior actions that firms take in the S-C-P framework (DHP, 1986b). These data were not available for this analysis. However, with the exception of the consumer-oriented segments that include tissue and fine writing papers, advertising in the industry is relatively unimportant because the bulk of pulp, paper and paperboard products are for producer markets.

IV. Data and Estimation Results

The data for this study were obtained from the Forest Products Laboratory (FPL), the U.S. Department of Agriculture.[23] The measure of industry concentration, CR4_FPL, is calculated using the annual capacity data on all US pulp, paper, and paperboard mills

[23] For more detailed data description, refer to "United States Paper, Paperboard, and Market Pulp Capacity Trends by Process and Location, 1970-2000," report compiled by the Forest Products Laboratory at Wisconsin, Madison under auspices of the USDA.

for 1970-2000. Some 20,000 observations were aggregated into the panel of CR4_FPL for pulp, paper, and paperboard sectors. The PCM measure is calculated using the data available from the National Bureau of Economic Research (Bartlesman and Gray, 1998).

Table 1 presents descriptive statistics for the model variables. The average PCMs varied little by sector, ranging from a low of 29.4% for the paper sector to a high of 32.2% for the pulp sector. However, for a given sector, there was considerable variation throughout the sample period. With a standard deviation of 8.0, the most volatile PCM was in the pulp sector, followed by the paperboard and paper sector with 5.7 ad 5.1 standard deviations respectively.

Among the three sectors, pulp mills were most concentrated and endured the greatest impact of foreign competition. On average, its top four pulp producers garnered 42.7% (with 3.4 standard deviations) of the domestic market with imports accounting for an average of 34.7% domestic sales. The paper sector was least concentrated (with a mean of 26.3% and 2.6 standard deviations). Paper imports, on average, account for 15.4% of the total domestic sales and were relatively stable over the sample period (1.4 standard deviations). With a four-firm concentration ratio averaging 28.2%, the paperboard market has a market structure similar to the paper sector. In contrast, however, the paperboard sector has little foreign competition, with imports accounting for only 1.1% (and 1.2 standard deviations) of domestic sales.

Throughout the period, the average unemployment rate, a proxy of business cycles, averaged 6.3% with 1.4 standard deviations, and real environmental expenditures averaged $624.2 million per year.

An analysis of the correlation matrix among these variables indicated a relatively high level of correlation (.82) between import intensity and market concentration and very little correlation (.09) between import intensity and PCM. There was also small correlation (.31) between PCM and market concentration.

Models I – VI in Table 2 provides regression results for the empirical structure-performance model defined in (8). Model I present regression results for a simple pooled OLS model, where it is seen that an increase in four-firm concentration has an expected positive sign, indicating that a one percentage point increase in the concentration ratio leads to a 0.52 percentage point increase in the price-cost margin. Also, as expected, import competition reduces the price-cost margin, as it lowers the market power of domestic producers.[24] Based on the model, a one percentage point increase intensity reduces the price-cost margin by 0.14 percentage points.

On the other hand, environmental expenditures seem to have positive and significant effect on industry PCMs. A hundred million dollar increase in real environmental expenditures increases industry PCMs by 0.79 percentage points. Given that Environment Expenditures are counted as part of fixed costs, the positive sign suggests that firms increase prices to pass at least part of these costs forward to customers in the form of higher prices, which would show up as a higher PCM.[25]

Columns II – VI in Table 2 provide additional regression results for alternative specifications. To avoid omitted variable bias, a fixed effects model for panel data

[24] Recall from the previous section that import intensity is lagged one year in order to reduce potential endogeneity problems given that the price-cost margin and import intensity variables are defined in terms of domestic shipments.

[25] It is also possible that, since higher profit margins provide firms with more capacity to make environment expenditures, environment expenditures are also endogenous. However, based on the time pattern, as discussed in section III, high level of environment expenditures followed almost immediately the related legislations, thus we treat this variable as exogenous.

should generally be preferred. Column II in Table 2 reports the result based on fixed effects model.[26] The resultant coefficient for CR4_FPL becomes 0.73 and statistically significant, higher than the OLS estimate. However, the F-test cannot reject the null hypothesis of no fixed effects. Additionally, the effect of import competition becomes insignificant in the fixed effects model. Since import pattern depends on sectors, e.g., the pulp sector has high import and paperboard sector has very low imports and this pattern is almost time-invariant, the import intensity may be highly correlated with sectoral fixed effects, and thus possibly cause the change in the significance levels.

To reduce the multicollinearity problem, we use import adjusted CR4_FPL in the model. The estimated effect of industry concentration on the price-cost margins increases to 0.79, and is highly significant. This is expected because the measured effect incorporates both impacts from domestic concentration and from import competition. In this specification, the fixed effects are again insignificant.

We also apply the random effects model, because it is generally more efficient when time invariant error components present. The result from random effects model is reported in Column IV of the Table 2. The estimated coefficient for CR4_FPL becomes 0.61, close to the OLS estimates reported in Column I, and the estimated coefficients for other variables are close to the OLS estimates as well. This is not surprising, because pooled OLS and random effects model should be equivalent in the absence of fixed effects. The Hausman test on random effects cannot reject the random effects model.

[26] An alternative specification is to include annual time dummy as well, which requires additional 27 time dummies and causes concern for the degrees of freedom. Our result shows that when annual dummies are included, most variables become insignificant. Therefore, we do not include those time dummies. In order to control for the time effects caused by, for example, business cycle, we will use unemployment rate as a proxy later.

Given the long-term nature of investment in the pulp and paper industry, it is unlikely that the current market concentration based on capacity will be correlated with the unobserved factors that affect the current price-cost margin. However, Froeb and Werden (1991) argue that capacity concentration can still be endogenous because of some feedback processes as investments in new capacity, research and development, and entry-exit. Using fixed effects model eliminates the bias from omitted time-invariant variables, yet it does not eliminate the bias stemming from correlation between the concentration measure and the idiosyncratic errors.

In order to check the possible endogeneity of the current CR4_FPL, we employ Instrument Variable (IV) estimation and use different instruments (Columns V and VI, Table 2). In Model V, we use one-year lagged value of the CR4_FPL as an instrument; and in Model VI, lagged CR4_FPL and the number of mergers in the previous year are both used as instruments.[27] In Model VI with two instruments, it is possible to conduct the test on overidentifying restrictions. The test cannot reject the null hypothesis at 10% level, and thus does not reject the validity of the instruments used. The results based on two sets of instruments are very close. Moreover, they are very similar to the OLS estimates in Column I. This finding is consistent with the literature that the results using OLS and 2SLS techniques are similar (Weiss 1989 and Schmalensee 1989).

Based on the above results, we find that market concentration has a positive and significant effect on price-cost margins in the pulp and paper industry. It appears that if the market concentration increases by one percentage point, the PCM will increase 0.5-0.6 percentage points based on most robust estimates. However, it is believed that this

[27] The number of mergers is calculated from the FPL data.

relationship is not stable and changes with business cycles. In particular, during the period of economy expansion, industry PCM may increase. In order to capture the cyclical pattern, DHP (1986a, 1986b) use the aggregated unemployment rate as a measure of cyclical activity to study the intertemporal behavior of margins. Following this approach, we also use unemployment rate to proxy the business cycle.[28] Additionally, unemployment rate can serve as a proxy for annual fixed effects, as discussed above. The results are presented in Table 3.[29]

In Model I, current unemployment rate and its interaction with CR4_FPL are included. The estimated coefficient for the interaction term is negative and significant at the 10% level. The result is consistent with DHP (1986b) findings of positive effect of the unemployment rate and negative effects of its interaction with industry concentration. When unemployment is high and the economy is in a downturn, the PCM tends to be lower as the sluggish demand makes it more difficult for firms to maintain the prices. When the unemployment rate is at its average (6.3%), one percentage point increase in CR4_FPL will result in 0.49 percentage point increase in price-cost margin. However, the effect becomes 0.69 when the economy is expanding (unemployment is at its minimum of 4%); and becomes 0.19 when the economy is in recession (when the unemployment is measured at its maximum of 9.7%).

Since unemployment is generally viewed as a lagging indicator of business cycle, the current unemployment rate may be a good indicator of the previous economic

[28] The unemployment rate is taken from the Current Population Survey published by the Bureau of Labor Statistics.

[29] Since estimates from the random effects model and 2SLS estimation are similar to the OLS estimates, and the F-test cannot reject the hypothesis of no fixed effects and Hausman test cannot reject random effects model, these results indicate that OLS estimation should be equivalent to the random effects model. Therefore, for simplicity, the results in Table 4 are based on the OLS estimation.

condition. To examine this possibility, in Model II, a leading unemployment is used to replace the current unemployment. The coefficient of the interaction term is still negative but becomes statistically insignificant. The change could mean different cyclical pattern, or could simply be caused by multicollinearity. Since in both models, unemployment itself is not significant, in order to save degrees of freedom and to reduce multicollinearity, we drop this term in model III and IV. In this case, the results are very similar based on these two models, indicating a pro-cyclical pattern of market concentration on the PCM. In other words, the mark-up power from market concentration becomes weaker in recession and stronger in expansion, using either current or leading unemployment rate, although the pro-cyclical pattern is stronger when using current unemployment rate to proxy business cycle. In a normal situation (measured at average unemployment rate), the effect of industry concentration on price-cost margins falls in the range of 0.4 to 0.5, and is highly significant.

The effects of import intensity and environmental expenditures are also very robust across the models. When import intensity increases by one percentage point, the price-cost margin will decline by 0.16 to 0.21 percentage points, and is highly significant. Clearly, the impact of import competition is much smaller than that of the domestic market concentration. On the other hand, the environmental expenditures due to regulation actually increase price-cost margin, as the industry may pass on the costs to its customers through higher prices. On average, when the total expenditures on environment protection increase by 100 million dollars, the PCM will rise by 0.62 to 0.76 percent points.

V. Other Results

Traditionally, studies on industry structure and price-cost margins (DHP 1986a, 1986b, Salinger 1990) use the concentration measure CR4 from the Census. However, the Census CR4 series are typically interpolated as the data are available at five year intervals only. The interpolated values will generally differ from the true market concentration and contain measurement errors. In an OLS type regression, either in a simple OLS analysis or in fixed effects panel data regression approach, the measurement error in the regressor will cause attenuation bias. Since the effect of market concentration on price-cost margin is generally positive, the attenuation bias will cause an underestimation of the true effect. Additionally, since the Census CR4 series are obtained using data on shipments, they are likely to cause endogeneity as the PCM values are also based on shipments.

The examination of the difference in the performance of the two concentration measures renders much weaker effect of market concentration on industry PCM. Specifically, one percentage point increase in Census-based CR4 gives 0.28 percentage increase in the industry PCM in contrast to 0.52 percentage point increase provided by the capacity-based CR4.

Similarly, testing for the attenuation bias, by using the average of the interpolated Census CR4 and the FPL_CR4, indicates considerable measurement error contained in the Census CR4 data. In general, the measurement error in the average of the two concentration measures should have a smaller variance and the resulting attenuation bias should be smaller. The estimated coefficient for the average CR4 is 0.41, which is larger

than that based on the Census CR4 and smaller than that based on the FPL CR4. Thus, measurement error in the interpolated CR4 is much greater than in the FPL data.

Finally, the interpolated Census CR4 underestimates the true effect of concentration on price-cost margin. This is determined by using the capacity-based CR4 as an instrument for Census CR4 in a two-stage least squares estimation (2SLS). In this case, the FPL CR4 serves as a second measure of the true CR4 to correct for attenuation bias caused by the measurement error. Since it is likely that the measurement errors in the capacity-based FPL CR4 will not be correlated with that in the Census CR4, and the FLP CR4 should be exogenous to the model as it will not be correlated with other contemporary unobserved factors (such as business cycle factors), the FPL CR4 should be a valid instrument. The resulting estimate of Census CR4 is 0.46, much larger than the estimate 0.28 but very close to the estimate of 0.52. Hence, the interpolated Census CR4 underestimates the true effect of concentration on price-cost margin.

VI. Conclusion

In recent years, industry players turn to merger and acquisition strategy in order to improve profitability. As a result of accelerated consolidation activities, the market concentration in pulp, paper and paperboard sector has been rising steadily. Therefore, the impact of consolidation on profit margins as well as on market power has important implications for the industry and for government regulatory agencies.

We found that on average when market concentration measured by CR4 increases one percentage point, price-cost margin will increase 0.5 to 0.6 percentage points. The effect, however, fluctuates with business cycle and show a pro-cyclical pattern. It

becomes 0.69 when the economy is expanding and 0.19 when the economy is in recession. In addition, increasing import competition decreases the ability of firms to increase their operating profits. When import intensity increases by one percentage point, the price-cost margin will decline by 0.16 to 0.21 percentage points. Finally, our results show that industry-specific environmental regulations have positive and significant effects on the PCMs, which is likely to be caused by shifting the environment protection costs to consumers through higher prices.

In the past three decades, price-cost margins generally show a slight trend of increase in all three sectors of the pulp and paper industry. The average price-cost margin for the three sectors is approximately 31%. However, when it comes to actual profits and returns to investment, the trend has not been so optimistic. It is generally viewed that the profitability for the whole industry is not getting better. The profit rate, measured by the ratio of net profits after taxes to net worth, for paper and allied industries has been flat since 1970.[30]

What factors have contributed to such a puzzling situation? It is known that price-cost margin only measures short-run returns to sales, and is different from the measure of actual profits. One explanation in the literature for the joint occurrence of relatively high price-cost margin and low actual profit rates is chronic excess capacity (Hall 1986; CPBIS 2003).[31] In the pulp and paper industry, since capital recovery and fixed costs are a large part of the costs, excess capacity can cause a large amount of interest cost, and thus lowers profits rate.

[30] Paper and allied industry also includes forest product industry. Due to the data limitation, we cannot conduct an in-depth investigation on the relationship between actual profits and PCM here.
[31] State of the North-American (and Maine) Pulp and Paper Industry—An Update and Outlook," Center for Paper Business and Industry Studies, 2003.

Additionally, environment regulations causes large amount of environmental expenditures. Although, environment expenditures have a positive effect on price-cost margin as shown in the models, it may not increase actual profits. As suggested by DHP (1988), high margin and low profits can also be explained by the identity of fixed costs. Environment expenditures are indeed a part of "non-capital fixed costs."

Finally, consolidation may improve efficiency by lowering costs, and thus increase price-cost margin. Price-cost margin will increase when price is higher or when the variable costs are lower. Li and Luo (2004) estimate the effect of consolidation on price level in the U.S. containerboard industry and find that industry concentration does not have a significant effect on the price, after controlling for other demand and supply side factors. If this result can be generalized to the pulp and paper sector, then we have some evidences that consolidation helps lower variable costs. Because of data limitations, however, we do not know whether consolidation helps reduce such overhead costs as administrative and advertisement expenses. We will leave it for future work to investigate the effect of consolidation on actual profitability in the pulp and paper industry.

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Table 1 Descriptive Statistics

Variable	N	Mean	Standard Deviation	Min	Max
Pulp Mills					
PCM, %	31	32.2	8.0	17.9	51.4
FPL CR4, %	31	42.7	3.4	36.3	50.8
Import Intensity, %	29	34.7	4.5	27.7	43.8
Number of Mergers	31	1.7	1.8	0.0	6.0
Paper Mills					
PCM, %	31	29.4	5.1	21.8	39.9
FPL CR4, %	31	26.3	2.6	22.0	30.9
Import Intensity, %	29	15.4	1.4	13.2	17.9
Number of Mergers	31	9.6	7.5	0.0	27.0
Paperboard Mills					
PCM, %	31	31.7	5.7	23.3	42.3
FPL CR4, %	31	28.2	6.4	22.2	46.1
Import Intensity, %	29	1.1	1.2	0.0	3.6
Number of Mergers	31	7.6	7.1	0.0	35.0
All-Sector Variables					
Real Environmental Expenditures (million dollars, in 1987 dollar)	28	624.2	287.8	220.3	1203.7
Unemployment Rate	31	6.3	1.4	4.0	9.7

Table 2
Structure Performance Estimation Results

Variables	**I** OLS	**II** Fixed Effects	**III** OLS	**IV** Random Effects	**V** 2SLS	**VI** 2SLS
FPL-CR4	0.52	0.73		0.61	0.52	0.51
	(4.16)	(3.74)		(3.52)	(3.61)	(3.56)
FPL-CR4 Import Adjusted			0.79			
			(4.09)			
Import Intensity Lagged	-0.14	0.14		-0.21	-0.21	-0.21
	(-1.99)	(0.56)		(-1.69)	(-2.58)	(-2.53)
Environmental Expenditures	0.79	0.65	0.74	0.74	0.76	0.76
	(4.11)	(3.00)	(3.62)	(3.43)	(3.44)	(3.44)
Pulp Dummy		-15.48	-0.53			
		(-1.79)	(-0.32)			
Paper Dummy		-4.31	0.7			
		(-1.10)	(0.58)			
Constant Term	18.11		5.82	10.16	13.13	13.31
	(7.73)		(1.32)	(2.16)	(3.61)	(3.66)
Sampe Size	84	84	84	84	84	84
F-value	7.71	2.06	9.03		9.38	9.25
Adjusted R	0.20		0.28			
Hausman Test for Random Effects				M-value, 3.24		
				p-value, 0.36		
Overidentifying Restrictions Test						F-value, 2.76
						p-value, .101

Notes

1. Heteroskedasticity-robust t-statistics are in parentheses.
2. In Column V, FPL CR4 is used as a regressor and lagged FPL CR4 is used as an instrument.
3. In Column VI, FPL CR4 is used as a regressor and Lagged FPL CR4 and the lagged number of mergers are used as instruments.

Table 3
Cyclical Effects of Industry Concentration

Variables	**I** OLS	**II** OLS	**III** OLS	**IV** OLS
FPL-CR4	1.05	0.54	0.78	0.65
	(2.72)	(1.16)	(5.22)	(4.43)
Import Intensity Lagged	-0.19	-0.17	-0.19	-0.17
	(-2.91)	(-2.38)	(-2.94)	(-2.39)
Environmental Expenditures	0.63	0.75	0.62	0.76
	(3.46)	(4.03)	(3.46)	(4.14)
Current Unemployment	1.31			
	(-0.88)			
Leading Unemployment		-0.56		
		(0.29)		
Current Unemployment * FPL CR4	-0.09		-0.05	
	(-1.68)		(-3.44)	
Leading Unemployment * FPL CR4		-0.02		-0.04
		(-0.26)		(-2.20)
Constant Term	6.49	18.80	15.25	15.10
	(0.60)	(1.37)	(5.66)	(5.26)
Sampe Size	84	84	84	84
F-value	9.78	7.79	12.13	9.82
Adjusted R	0.35	0.29	0.35	0.30

Notes
1. Heteroskedasticity-robust t-statistics are in parentheses.