Product Market Competition and the Efficient Use of Firm Resources

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October 2014

Abstract

This paper empirically examines whether product market competition plays a significant role in providing incentives for the efficient use of firm resources by employing multidimensional measures of product market competition and firm efficiency. While previous studies have examined this issue using one-dimensional measures such as ROA and ROE, we evaluate firm efficiency using a frontier efficiency methodology. We find that product market competition seems to provide incentives for the efficient use of firm resources only when rivals are not expected to react aggressively to the actions of the competing firm. When firms compete in industries with a high level of strategic interaction, they are forced to react constantly to the actions of rivals. This hinders the firm's ability to focus on efficiency.

JEL Classification: G10, G30, L11, L22, L25
Keywords: Product market competition, industry structure, strategic interaction, firm efficiency

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The authors are grateful to Jim Musumeci, Atul Gupta, Alan Marcus, Kristina Minnick, Husayn Shahrur, Ajay Subramanian, Anand Venkateswaran, and seminar participants at the 2012 Meetings of the Financial Management Association, Bentley University, and Boston College for their helpful comments.

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1. Introduction

This paper empirically examines whether product market competition plays a significant role in providing incentives for the efficient use of firm resources by employing multidimensional measures of product market competition and firm efficiency. While previous studies have examined this issue using one-dimensional measures such as ROA and ROE, we evaluate firm efficiency using a frontier efficiency methodology. That is, we measure firm efficiency relative to a 'best-practice' frontier comprised of the leading firms in an industry. Demerjian et al. (2012) argue that frontier efficiency methodology outperforms one-dimensional efficiency measures[1] in two key aspects. First, this methodology provides an ordinal ranking of relative efficiency compared to the Pareto-efficient frontier—the best performance that can be practically achieved. Parametric methods, such as regression analysis and ratio comparisons, estimate efficiency relative to average performance, which is decreased disproportionately by inefficient industry peers. Second, frontier efficiency methodology calculates efficiency without imposing an explicit, ad hoc weighting structure, unlike widely used efficiency measures such as ROA, which often assume that all inputs and outputs are equally valuable across firms.

Similarly, previous studies that examine product market competition predominantly use only one aspect of industry structure: competition among industry rivals, which is often measured by industry concentration (e.g., Haushalter et al, 2007: Hoberg and Phillips, 2010a; Giroud and Mueller, 2010 and 2011; Chhaochharia et al., 2012; Valta, 2012). More recently, researchers have used improved measures of product market competition by employing a text-based analysis of 10K product and business descriptions (e.g., Hoberg and Phillips, 2010b;

[1] Often used one-dimensional measures of firm efficiency include return on assets (ROA), the ratio of sales to assets, the ratio of cost of goods sold (COGS) to sales, and the ratio of selling, general, and administrative (SG&A) expenses to sales (e.g., Ang et al., 2000 and Chhaochharia et al., 2012).

Hoberg et al., 2014). Yet, competition for profits goes beyond industry rivals to include other competitive forces. In this paper, we capture multiple aspects of industry structure using Porter's Five Forces. Porter's seminal paper in the Harvard Business Review (Porter, 1979) draws upon industrial organization (IO) literature[2] to derive five forces that shape the industry competition: rivalry among existing competitors, bargaining power of customers, bargaining power of suppliers, threat of new entrants, and threat of substitute products. We examine the effects of all five forces, and their combined effect on the efficient use of firm resources.

Further, to examine how strategic decisions affect the competitive environment and therefore the efficient use of firm resources, we capture the extent of strategic interaction in an industry by computing the competitive strategy measure (CSM) developed by Sundaram et al. (1996). CSM is a measure of responsiveness of a firm's profits to changes in its competitors' actions. If there is a positive correlation between a change in a firm's profit margin and a change in the firm's rivals' combined sales, the firm is said to compete in strategic complements. When the correlation is negative, the firm is said to compete in strategic substitutes. Porter (2008) argues that the degree of strategic interaction affects profitability through the way it influences the five forces. Thus, we evaluate subsamples of our firms based on the competitive strategy measure to examine the effects of Porter's Five Forces on firm efficiency in these subsamples.

We find that the combined effect of Porter's Five Forces on firm efficiency is weak at best. However, when we introduce strategic dynamics to the analysis, we find a positive and significant relationship between the intensity of Porter's Five Forces and firm efficiency in industries with a low level of strategic interaction and a negative and significant relationship in industries with a high level of strategic interaction. That is, product market competition seems to provide incentives for the efficient use of firm resources only when rivals are not expected to

[2] These early papers include Mason (1939), Bain (1956), and Bain (1968).

react aggressively to the actions of the competing firm. When firms compete in industries with a high level of strategic interaction, they are forced to react constantly to the actions of rivals. This hinders the firm's ability to focus on efficiency. These results are robust in the subsample of manufacturing industries and using alternate measures of industry concentration. Results are also robust to an alternative measure of strategic interaction, a text-based measure developed by Hoberg et al. (2014).

Our study confirms the importance of capturing multiple dimensions of industry structure in empirical work and contributes to the literature that focuses on the direct relation between product market competition and firm efficiency (e.g., Caves and Barton, 1990; Nickell, 1996; Fabrizio et al., 2007). It also provides empirical support for the literature on competitive strategy and strategic dynamics (e.g., Porter, 1979; Brandenburger and Nalebuff, 1996). Finally, this study is part of a growing empirical literature that examines the effect of product market competition on firm behavior (e.g., Kedia, 2006; Lyandres, 2006; Haushalter et al., 2007; Kale and Shahrur, 2007; Karuna, 2007; Hoberg and Phillips, 2010a; Chod and Lyandres, 2011; Grullon and Michaely, 2012; Fresard and Valta, 2014; Hoberg et al., 2014).

The remainder of the paper is organized as follows. Section 2 recaps the literature on the relation between product market competition/strategic interaction and firm efficiency and presents our hypotheses. Section 3 describes the data and methodology used in the analysis. Section 4 discusses the results of the analysis. Finally, Section 5 concludes the paper.

2. Related Literature and Hypotheses Development

2.1. Competition and Firm Efficiency

Early scholars such as Alchian (1950) and Enke (1951) argue that competition in the product market is a very powerful force for ensuring the survival of the fittest. The crucial element for survival is a firm's position relative to the actual competitors, not some hypothetically perfect competitors. Those who are relatively better than their actual competitors survive; those who are not disappear. Alchian also suggests that survival does not require proper incentives, but may rather be result of fortuitous circumstances.

Studies that followed (e.g., Winter, 1971; Hart, 1983; Holmstrom, 1982; Nalebuff and Stiglitz, 1983; Scharfstein, 1988; Hermalin, 1992) also argue that an increase in competition helps correct a firm's agency problems. For example, Hart (1983) assumes there to be two types of firms in an industry: managerial firms, in which there is a principal-agent problem, and entrepreneurial firms, in which the principal runs the firm. When costs are low, entrepreneurial firms expand output whereas managerial firms have managers who take advantage of the good times to slack. If the proportion of entrepreneurial firms is high, industry output in good times (low cost) is high, industry prices are low, and the potential for managerial slack in the managerial firms is low. Hence, increased competition leads to less managerial slack.

Scharfstein (1988) shows that the effect of competition on incentives depends critically on the specification of managerial preferences.[3] Similarly, Hermalin (1992) finds that the effects of competition on executive behavior can be decomposed into four effects, each of which is of potentially ambiguous sign. These results could be interpreted as a partial characterization of the conditions under which competition is beneficial or harmful.

Empirical evidence on the direct relation between product market competition and productive efficiency of firms is fairly thin. Nickell (1996) argues that broad-brush examples of the power of competition are more persuasive than based on econometric evidence. He provides the following examples to support his argument: (i) the low level of productivity in Eastern Europe relative to that in Western Europe is due to repressive forces of market competition, (ii)

[3] In Hart's (1983) model, managerial income is independent of competition, and managers care only about reaching a given subsistence level of income. Scharfstein (1988) shows that if managerial utility is increasing in income, then Hart's main result, that product market competition reduces managerial slack, can be reversed.

Japanese success stories (e.g., Japanese cars, motorcycles, cameras, video recorders, and musical instruments) discussed in Porter (1990) are largely due to intense domestic competition, and (iii) significant productivity gains generally follow deregulation (e.g., as in the U.S. airline industry).

Caves and Barton (1990) use a frontier production function technique to estimate efficiency for 350 U.S. manufacturing industries and report that an increase in market concentration above a certain threshold tends to reduce technical efficiency. Nickell (1996) analyzes 670 U.K. companies and presents evidence that competition, measured by increased numbers of competitors or by lower levels of rents, is associated with a significantly higher rate of total factor productivity growth.[4] Fabrizio et al. (2007) examine regulatory restructurings of U.S. electric generating plants and suggest that there are medium-term technical efficiency gains from replacing a regulated monopoly with a market-based industry structure. In particular, publicly owned plants that are largely insulated from regulatory reforms experience the smallest efficiency gains, whereas investor-owned plants in states that restructure their wholesale electricity markets improve the most.

Studies that examine firm efficiency in a financial context, most frequently use efficiency measures such as ROA, the ratio of SG&A expenses to sales, and the ratio of sales to assets (e.g., Ang et al., 2000; Chhaochharia et al., 2012). Consistent with the notion that product market competition is a close substitute for internal governance, Chhaochharia et al. (2012) find that the approval of Sarbanes Oxley Act is associated with significantly larger increases in operational efficiency in firms that belong to concentrated industries than in firms that belong to competitive industries. Demerjian et al. (2012) argue that the technical efficiency measure from frontier efficiency methodology outperforms these kinds of one-dimensional performance measures

[4] Total factor productivity growth is measured as the change in total outputs net of the change in total input usage. In contrast, the concept of technical efficiency (one that we use in this paper) measures inputs and outputs in relation to a benchmark, i.e., the optimal input-output usage in an industry.

because it summarizes financing, production, marketing, and innovation decisions made by a firm in a single statistic that controls for differences among firms. Given the drawback of the one-dimensional models, we measure firm efficiency using a frontier efficiency methodology.

Likewise, studies that examine product market competition generally use only one aspect of industry structure: competition among industry rivals, which is regularly measured by industry concentration (e.g., Haushalter et al., 2007; Hoberg and Phillips, 2010a; Giroud and Mueller, 2010, 2011; Chhaochharia et al., 2012; Valta, 2012).[5] Recently, researchers have made significant progress in improving the measures of product market competition using a text-based analysis of 10K product and business descriptions (e.g., Hoberg and Phillips, 2010b; Hoberg et al., 2014). However, competition for profits goes beyond industry rivals to include other competitive forces. To capture the multiple aspects of an industry's structure, we use the Porter's Five Forces framework (Porter, 1979) to examine the effect of industry structure on product market competition. Specifically, Porter develops five forces that determine an industry's competitive structure: threat of industry rivals, threat of new entrants, threat of substitute products, bargaining power of suppliers, and bargaining power of customers.

Given the limitations of previous research, we use frontier efficiency methodology and Porter's multiple aspect measure of industry structure to examine the relation between product market completion and the efficient use of firm resources. Specifically, we test the following hypothesis:

<u>*Hypothesis 1*</u>*: Product market competition leads to improvement in firm efficiency.*

2.2. Strategic Interaction and Firm Efficiency

[5] Notable exceptions include Kale and Shahrur (2007), who look at the effects of customer power and supplier power in addition to the focal industry concentration on firms' capital structure, and Karuna (2007), who examines the effects of product substitutability, market size, entry costs, and industry concentration on managerial incentives.

Porter's Five Forces framework has been criticized for its failure to take full account of competitive interactions among firms (e.g., Brandenburger and Nalebuff, 1996). They note that the essence of strategic competition is the interaction among players, such that the decisions made by any one player are dependent on the actual and anticipated decisions of the other players. Competitive interactions are often examined using the Herfindahl-Hirschman Index (HHI). However, HHI it can be misleading as a measure of the extent of competitive interaction since it is more a measure of industry concentration. Indeed, the fewer firms operating in an industry (i.e., the higher the concentration), the higher the extent of competitive interaction. Yet, Lyandres (2006) notes that high industry concentration could also be due to the high variation in the sizes of industry participants, which reduces the expected influence of firms' actions on their rivals. Similarly, industries with low concentration could consist of a large number of similarly sized firms, which cannot affect one another's actions, or a few large firms and numerous small firms, where large firms' choices can affect their large rivals' actions. Therefore, the relation between the industry concentration and the extent of interaction among firms in product markets is ambiguous.

While we use HHI in the paper as a measure of industry concentration, we do not rely on it as our sole measure of competitive or strategic interactions among firms. Porter (2008) points out that the presence of complements also has an ambiguous effect on barriers to entry, threat of substitutes, power of suppliers and customers. Since strategic interactions influence all five forces, we capture and control for this additional aspect of industry structure in our analysis.

Strategic interactions among firms in their product markets are classified as strategic substitutes or strategic complements (Bulow et al., 1985). Firms are said to compete in strategic substitutes whenever an aggressive play by a firm lowers its rivals' marginal profits. Likewise, firms are said to compete in strategic complements when an aggressive strategy by a firm raises its competitor's marginal profits. Sundaram et al. (1996) are the first to develop an empirical measure of strategic interactions. Their competitive strategy measure (CSM) captures the responsiveness of a firm's profits to changes in its competitors' actions. Thus, CMS is directly related to the cross-partial derivatives of firms' values with respect to their own and their rivals' strategies. If the correlation between the change in a firm's profit margin and the change in its rivals' combined sales is positive, the firm is classified as competing in strategic complements. When it is negative, the firm is classified as competing in strategic substitutes.

Sundaram et al. (1996) examine the effect of R&D expenditure announcements on stock prices of announcing firms. They find that the average announcement effect of an R&D expenditure is not significantly different from zero. However, when the announcing firm competes in strategic substitutes, the announcement effect of R&D spending is positive; when the firm competes in strategic complements, the announcement effect is negative. Lyandres (2006) improves on the Sundaram et al.'s CSM measure by incorporating industrywide shocks and examines the relation between firms' capital structure and the intensity of competitive interaction, which is proxied by the absolute value of the adjusted CSM measure. He finds that, regardless of the type of strategic interaction, firms' leverage is positively related to the extent of competitive interaction within their industries.

Kedia (2006) finds that strategic substitutes decrease the pay for performance incentives of CEOs, whereas strategic complements significantly increase CEO pay for performance incentives. Chod and Lyandres (2011) examine firms' incentives to go public in the presence of product market competition. Focusing on competition in quantities (strategic substitutes), they find that the proportion of public firms in an industry is positively related to the degree of competitive interaction among firms in the output market.

Following literature that highlights the importance of strategic dynamics in the competitive environment (e.g., Brandenburger and Nalebuff, 1996; Sundaram et al., 1996; Lyandres, 2006; Kedia, 2006), we test the following hypothesis:

Hypothesis 2: The extent of strategic interaction in the industry, regardless of the type of strategic interaction, affects the relation between product market competition and firm efficiency.

3. Data and Methodology

3.1. Data

Sources of data used in the paper include Compustat Fundamentals (Annual and Quarterly), Census of Manufactures from the Census Bureau, and Benchmark Input-Output data from the Bureau of Economic Analysis. The initial sample consists of all firms in Compustat, except financials and utilities, during the sample period 1988–2010. We classify product markets (industries) at the four-digit SIC code level. As pointed out by Clarke (1989) and Kahle and Walkling (1996), some four-digit SIC codes may fail to define sound economic markets. To minimize such concerns, we follow Clarke (1989), Karuna (2007), and Fresard (2010) and exclude four-digit SIC codes ending with zero and nine. Our final sample consists of 57,926 firm-year observations and 4,035 industry-year observations. We winsorize all variables at the first and ninety-ninth percentiles to reduce the effect of outliers.

3.2. Measure of Firm Efficiency

Our definition of efficiency is based on the firm's ability to fully utilize its resources. Ideally two firms with similar characteristics and opportunity sets should have the same level of production, Y*. However, in reality some firms will not use their resources as efficiently as others. As a result a firm may be at a production level Y, which is less than Y*.[6] The difference between Y* and Y is firm inefficiency.

To measure efficiency as a firm's deviation from Y*, we need a credible benchmark of Y*. In addition, to avoid an inequitable comparison of companies with different opportunities and characteristics, the benchmark needs to hold constant the firm's opportunity set and characteristics. Traditional measures of firm performance (e.g., ROA) are constrained to a single input and output and therefore are unable to control for differences among firms' input-output mix. Frontier efficiency methods, in contrast, provide a mechanism to benchmark Y* and control for differences in input usage and output production in multi-input, multi-output firms using a rigorous approach derived from micro-economic theory (Aigner et al., 1977; and Charnes et al., 1978). Frontier efficiency methods form a "best practice" frontier that provides the maximum output based on a portfolio of inputs. This frontier function serves as the benchmark hypothetical value Y* that a firm could obtain if it were to match the production performance of its best-performing peer(s). A firm's shortfall from the frontier is a measure of inefficiency.

We estimate frontier efficiency using a mathematical programming approach, Data Envelopment Analysis (DEA). Given a certain level of inputs and outputs, DEA compares each firm to its 'best practice' peers and provides an efficiency score from zero to one. A firm is classified as fully efficient (Efficiency = 1.0) if it lies on the frontier and inefficient (0 < Efficiency < 1) if its outputs can be produced more efficiently by another set of firms. Details on estimating efficiency using DEA are available in Appendix A.

To measure the efficiency of all publicly-traded firms, we need measures of inputs and output that are applicable to all publicly-traded firms. Following Demerjian et al. (2012, 2013), we use revenue (Compustat data item #12) as the output. Other papers have used Tobin's Q and

[6] This notion of inefficiency comes from the production efficiency and productivity literature, first introduced by Debreu (1951), Farrell (1957), and Koopmans (1951).

net income as measures of output. For example, Habib and Ljungqvist (2005) and Nguyen and Swanson (2009) measure output with Tobin's Q. Using Tobin's Q, however, may subject the efficiency measure to a potential misvaluation problem. That is, an irrational overvaluation of a firm's equity relative to its fundamentals may make the firm appear more efficient than it is in reality. In addition, Demerjian et al. (2012) argue against net income as an output since it is the aggregation of inputs and output (expenses and revenue). Lee and Choi (2010) also show that the inclusion of a redundant output variable (e.g., net income) does not change the DEA efficiency estimates. Moreover, the DEA linear program measures a firm's ability to maximize output (revenue) given a certain level of inputs (costs). Therefore, efficiency, in the context of our inputs and outputs, is a measure of the firm's relative performance in maximizing firm profits.

For the inputs, we again follow Demerjian et al. (2012, 2013) by considering items that contribute to the production of revenue. The first input is net property, plant, and equipment (PP&E, data item #8). The second input is capitalized operating leases, which is calculated as the discounted (at 10 percent) present value of five years of lease payments. The Compustat data items for the five lease obligations are #96, #164, #165, #166, and #167. The third input is the five-year capitalized value of R&D expense (data item #46). The capitalized value is calculated as $RD_{cap} = \sum_{t=-4}^{0}(1 + 0.2t) * RD_{exp}$. The fourth input is purchased goodwill, which is calculated as the premium paid over the fair value of an acquisition (data item #204). The fifth input is other acquired and capitalized intangibles (data item #33 – data item #204). The sixth input is cost of goods sold (COGS; data item #41). The seventh and final input is selling, general, and administrative costs (SG&A; data item #189). Demerjian et al. (2012, 2013) show that all of these inputs contribute to the generation of revenue and are affected by managerial ability, as each of the inputs is subject to managerial discretion.

We measure efficiency for all firms in Compustat (except for financials and utilities) during fiscal years 1988–2010. To be included in the final sample, firms must have no missing data for all input and output variables. Since we expect that firms in the same industry will have similar structures for converting capital into revenue, we estimate efficiency separately for each industry and year. This allows for cost functions to differ across the industries. We obtain a measure of efficiency for 173,305 firm-years. Although our final sample is much smaller due to additional data requirements (described below), we compute firm efficiency on as large a possible set of firms since it is the universe of firms that determines the 'best-practice' frontier.

3.3. Proxies for Industry Structure

3.3.1. Threat of Industry Rivals

The most commonly used measure of the industry competition is Herfindahl-Hirschman Index (HHI), where higher HHI implies weaker competition. We use Compustat based HHI as a primary measure of industry concentration. However, Ali et al. (2009) show that measures of industry concentration that rely solely on Compustat firms may lead to incorrect conclusions due to the omission of private firms from the computation of HHI. Therefore, we also use Census-based HHI (labeled as HHI-Census) as a measure of industry concentration for a subset of manufacturing industries. The Census of Manufactures publications provided by the U.S. Census Bureau report concentration ratios for hundreds of industries in the manufacturing sector. We collect data on the U.S. Census-based HHI index from Census of Manufactures publications for the years 1987, 1992, 1997, 2002, and 2007.[7] The data are for four-digit SIC industries (SIC codes between 2000 and 3999) for the years 1987 and 1992 and for six-digit North American Industry Classification System (NAICS) industries (NAICS codes between 311111 and 339999)

[7] Census of Manufacturers benchmark tables are only prepared every 5 years. The most recent (released in December 2013) Benchmark Input-Output table available is for 2007. It is typical for the Benchmark to take five to six years to release, due primarily to the lag in the source data used to derive those estimates (namely, Census data).

for the years 1997, 2002, and 2007. Unlike Compustat-based industry concentration measures, U.S. Census-based measures are constructed using data from all public and private firms in an industry and hence should better capture actual industry concentration.

The Census of Manufactures calculates the Herfindahl-Hirschman index of an industry as the sum of the squares of the individual company market shares of all the companies in an industry or the fifty largest companies in the industry, whichever is lower. Since the Census of Manufactures is published only once in every five years, we use the 1987, 1992, 1997, 2002, and 2007 Census-based concentration ratios for the periods 1988-1989, 1990-1994, 1995-1999, 2000-2004, and 2005-2010, respectively. This approach is similar to that used in several prior studies (Fresard, 2010; Giroud and Mueller, 2011).

For the period 1995–2010, we use concentration ratios from the 1997, 2002, and 2007 Census of Manufactures publications in which industry is defined using six-digit NAICS codes. Census-based HHI for six-digit NAICS industries and the total shipments for these industries reported in the Census of Manufactures can be used to calculate Census-based HHI for broader four-digit SIC industries. We do this by weighting Census HHI of component six-digit NAICS industries by the square of their share of the shipments of the broader four-digit SIC industry.

3.3.2. Threat of New Entrants and Threat of Substitutes

We measure the threat of new entrants by the entry costs each new entrant must incur to start production in the industry. Following Karuna (2007), we calculate the weighted average gross value of property, plant, and equipment for firms for which this is the primary industry (at the four-digit SIC code level) weighted by each firm's market share in this industry. Since the entry cost measure is highly skewed, we use log-transformed entry cost variable (labeled as ENTCOST) as a measure of threat of new entrants to the industry. The higher the level of entry cost, the lower the threat of new entrants.

To capture the threat of substitutes, we again follow Karuna (2007) and calculate industry level price-cost margins as industry sales divided by industry operating costs (labeled as DIFF). Industry sales are calculated as the sum of primary industrial segment sales, while operating costs include cost of goods sold, SG&A expenses, and depreciation and amortization. Industrial organization (IO) literature suggests that high (low) levels of price-cost margin (product differentiation or DIFF) signify low (high) levels of product substitutability. Thus, the higher the price-cost margin, the lower the threat of substitutes.

3.3.3. Bargaining Power of Suppliers and Customers

We use concentration of supplier (customer) industries as a measure of bargaining power of suppliers (customers), i.e., suppliers (customers) from concentrated industries are deemed more powerful compared to suppliers (customers) from less concentrated industries. We follow Kale and Shahrur (2007) who use a weighted average of the concentrations of all supplier (customer) industries. Specifically, for each firm in the i^{th} industry, the supplier power measure is defined as:

$$Supplier\ Concentration = \sum_{\substack{j-1 \\ i \neq j}}^{n} Herfindahl\ Index_j \times Industry\ Input\ Coefficient_{ji};$$

where n is the number of supplier industries, $Herfindahl\ Index_j$ is the sales-based Herfindahl index of the j^{th} supplier industry, and $Industry\ Input\ Coefficient_{ji}$ is the dollar amount of the j^{th} supplier industry's output used as an input to produce one dollar of the output of the i^{th} industry. Similarly, for each firm in the i^{th} industry, the customer power measure is:

$$Customer\ Concentration = \sum_{\substack{j-1 \\ i \neq j}}^{n} Herfindahl\ Index_j \times Industry\ Percentage\ Sold_{ji};$$

where *n* is the number of customer industries, $Herfindahl\ Index_j$ is the Herfindahl index of the j^{th} customer industry, and $Industry\ Percentage\ Sold_{ji}$ is the percentage of the i^{th} industry's output that is sold to the j^{th} customer industry.

Following Fan and Lang (2000) and Kale and Shahrur (2007), we use two data sources, the *Use* table of the benchmark input-output data from the Bureau of Economic Analysis and the Compustat database, to construct the supplier and customer industry variables described above. For any pair of supplier and customer industries, the *Use* table reports estimates of the dollar value of the supplier industry's output that is used as an input in the production of the customer industry's output. The *Use* table enables us to identify the firm's customer and supplier industries and the importance of each supplier/customer industry to the firm. We use the 1987, 1992, 1997, 2002, and 2007 *Use* tables for the periods 1988-1989, 1990-1994, 1995-1999, 2000-2004, and 2005-2010, respectively.

3.3.4. Combined Effects of Porter's Five Forces

While we can examine the effects of each of the five competitive forces listed above on firm efficiency individually to test our hypotheses, testing the combined effect of all five forces on firm efficiency engenders a more comprehensive approach that allows for more well-defined interpretations. Thus, we construct a single variable that encompasses all competitive forces in an industry, by converting measures of threat of existing rivals, threat of new entrants, threat of substitutes, and bargaining power of suppliers and customers into intensity scores for each industry and year.

To capture the intensity of the threat of existing rivals, we assign a score of 10 to industries in the bottom decile of the HHI variable (i.e., the least concentrated industries would see the most competition from industry rivals), 9 to the second decile of HHI variable, 8 to the third decile, and so on. For the threat of new entrants, we assign a score of 10 to industries in the bottom decile of ENTCOST variable (i.e., least costly entry into an industry would result in the highest threat from new entrants) and 1 to the top decile. To capture the threat of substitutes, we assign a score of 10 to industries in the bottom decile of the DIFF variable (i.e., the lowest level of differentiation implies the highest threat from substitutes) and 1 to the top decile. For the bargaining power of customers (suppliers), we assign a score of 10 to the industries in the top decile of the concentration of the customer (supplier) industries variable and 1 to the industries in the bottom decile. These intensity scores are labeled as PF1 Rivals, PF2 New Entrants, PF3 Substitutes, PF4 Customer Power, and PF5 Supplier Power, respectively. An all-encompassing, single measure of the product market competition is the sum of these five intensity scores (labeled as P5F).

Finally, to distinguish the effects of vertical and horizontal competitive forces, we create two additional measures called Vertical Competition and Horizontal Competition, where the Vertical Competition measure is the sum of the intensity of customer power and supplier power, and Horizontal Competition measure is the sum of the intensity of the threat of existing rivals, threat of new entrants, and threat of substitute products.

3.3.5 Degree of Strategic Interaction

As discussed above, Sundaram et al. (1996) develop a proxy (denoted competitive strategy measure or CSM) for whether firms compete in strategic complements or substitutes. Kedia (2006) and Lyandres (2006) modify this empirical proxy to control for the effect of industry shocks. Following Lyandres (2006) we estimate CSM such that for a given firm *i*, CSM is defined as:

$$\text{CSM}_i = \text{corr}\left[\frac{\Delta\tilde{\pi}_i}{\Delta\tilde{S}_i}, \Delta S_R\right], \qquad (1)$$

where $\Delta\tilde{\pi}_i$ and $\Delta\tilde{S}_i$ are the implied changes (between two consecutive quarters) in the profits and sales of the i^{th} firm, respectively, and ΔS_R is the change in the firm's product market rivals' combined sales between two consecutive quarters. CSM$_i$ is used as a proxy for the cross-partial derivative of a firm's profit with respect to its own and its rivals' sales. We then define industry CSM as the mean CSM$_i$ for all firms in a given industry. A positive (negative) CSM indicates that industry firms compete in strategic complements (substitutes). Lyandres (2006) shows that using the implied changes rather than the actual changes in profits and sales (i.e., $\Delta\tilde{\pi}_1$ and $\Delta\tilde{S}_1$ rather than $\Delta\pi_1$ and ΔS_1) reduces the bias in estimating CSM that can result from industry shocks. For instance, if the entire industry is subject to declining costs then $\frac{\Delta\pi_1}{\Delta S_1}$ and ΔS_2 will be positively correlated even if industry firms compete in strategic substitutes (Kedia, 2006).

The implied changes in profits and sales are estimated using the models in Lyandres (2006) as follows. First, the parameters (α_i and β_i) of the following model are estimated:

$$\frac{S_{i,t+1} - S_{i,t}}{S_{i,t}} = \alpha_i + \beta_i \left[\frac{\pi_{i,t+1}}{S_{i,t+1}} - \frac{\pi_{i,t}}{S_{i,t}} \right] + \varepsilon_{i,t} \quad (2)$$

The implied changes in profits and sales are then defined as:

$$\Delta\tilde{S}_i = S_{i,t+1} - \tilde{S}_{i,t} = S_{i,t+1} - S_{i,t}\left[1 + \hat{\alpha}_i + \hat{\beta}_i \left[\overline{\frac{\pi_{t+1}}{S_{t+1}}} - \overline{\frac{\pi_t}{S_t}} \right]\right] \quad (3)$$

$$\Delta\tilde{\pi}_i = \pi_{i,t+1} - \tilde{\pi}_{i,t} = \pi_{i,t+1} - S_{i,t}\left[1 + \hat{\alpha}_i + \hat{\beta}_i \left[\overline{\frac{\pi_{t+1}}{S_{t+1}}} - \overline{\frac{\pi_t}{S_t}} \right]\right]\left[\frac{\pi_{i,t}}{S_{i,t}} + \left[\overline{\frac{\pi_{t+1}}{S_{t+1}}} - \overline{\frac{\pi_t}{S_t}} \right]\right] \quad (4)$$

where $S_{i,t}$ and $\pi_{i,t}$ are total sales (Quarterly Compustat data item #2) and operating profits (data item #21 minus data item #5) of the i^{th} firm in quarter t, respectively, and $\overline{\frac{\pi_t}{S_t}}$ is the average industry profit margin in quarter t. Simply put, Equations 2, 3, and 4 are used to estimate the implied profits and sales that would be observed if the only change is in the firm's profit function induced by a particular shock. Equations 3 and 4 use the change in the average industry profitability $\left[\frac{\overline{\pi_{t+1}}}{S_{t+1}} - \frac{\overline{\pi_t}}{S_t}\right]$ to proxy for the shock affecting the firm's profitability.

The parameters in Equation 2 are estimated using the previous 20 quarters (at least 10 observations are required). Next, using Equations 3 and 4, we estimate $\Delta\tilde{\pi}_i$ and $\Delta\tilde{S}_i$ for the previous 20 quarters, which are then used to estimate CSM$_i$ (as defined in Equation 1) for each firm-year in a given four-digit SIC code industry. Finally, we obtain CSM (the mean of CSM$_i$) for each year and four-digit SIC code industry. Since Compustat's quarterly files do not include historical SIC codes, we get industry classification from the annual files (data item #324).

Based on the absolute value of the CSM measure, we classify firms into subsamples: one subsample includes firms in industries with above sample median absolute value of CSM (or industries with a high level of strategic interaction) and another includes firms in industries with below sample median absolute value of CSM (or industries with a low level of strategic interaction).

4. Empirical Analysis

4.1. Descriptive Statistics

Table 1 lists summary statistics for the firm-level variables. Panel A displays descriptive statistics for the input and output variables and Panel B reports descriptive statistics for the efficiency measure and other variables that are used as control variables. Data used to construct the control variables come from Compustat. They include firm size (natural log of market value of assets; Compustat data item #6–data item #60+data item #199*data item #54), fixed asset ratio (PP&E/Book value of total assets; data item #8/data item #6), market value leverage (Total debt/Market value of assets; data item #9+data item #34)/(data item #6-data item #60+data item #199*data item #54), ROA (Operating income before depreciation/Book value of total assets; data item #13/data item #6), and market-to-book ratio (Market value of total assets/Book value of total assets; data item #6-data item #60+data item #199*data item #54)/data item #6).

The mean (median) efficiency for sample firms is 0.72 (0.79). While our final sample size is much smaller (57,926 firm-year observations) than the initial sample with efficiency scores (173,305 firm-year observations), the mean (median) value of efficiency scores in the initial sample is very similar at 0.67 (0.78). These values are slightly higher than values reported in Demerjian et al. (2012).[8] There is a large variation in the values of efficiency scores across firms. Untabulated univariate analysis shows that industries with the highest average efficiency score over the years include metal cans (0.98) and glass containers (0.98). The lowest average values of firm efficiency belong to biological products, except diagnostic substances (0.34) and commercial physical and biological research (0.41).

Table 2 presents the summary statistics for the industry-level variables used in the analysis. Panel A reports descriptive statistics for the raw industry variables, including industry concentration ratio HHI (Compustat based), industry concentration ratio HHI–Census, competitive strategy measure CSM, its’ absolute value (Abs(CSM)), entry cost measure ENTCOST, product differentiation measure DIFF, customer power measure, and supplier power measure. The mean (median) HHI for the sample industries is 0.34 (0.29), which is much higher than Census-based HHI, where the mean (median) value is 0.07 (0.06). This is expected because the Census HHI measure includes private firms in the industry. The sample mean (median) for the CSM measure is -0.03 (-0.02) and minimum (maximum) value is -0.99 (0.95) suggesting that within industries there is an almost even split between firms that compete as strategic substitutes

[8] Demerjian et al. (2012) estimate firm efficiency similarly by industry, but not by year. They report an average (median) efficiency score of 0.60 (0.59).

and firms that compete as strategic compliments. This is consistent with Sundaram et al. (1996) and Lyandres (2006). The mean (median) value for ENTCOST is 6.74 (6.64) and for DIFF is 1.58 (1.12), which are very similar to values reported in Karuna (2007). Low values for ENTCOST signify a high threat of new entrants, while low levels of DIFF signify high levels of product substitutability. Finally, the mean (median) value for Customer Power is 0.11 (0.08) and for Supplier Power is 0.12 (0.10), which are in line with values in Kale and Shahrur (2007) as well. Low levels of Customer (Supplier) Power mean that the customer (supplier) industries are less concentrated and therefore, they have less bargaining power.

Panel B reports intensity score transformations for the Porter's Five Force variables. The intensity scores range from one to ten, except for the Porter's Five Forces variable, which is sum of the five intensity scores. The values for each of the five forces have a mean that is close to 5 and a median of 4, 5, or 6. Thus, distributions of the five forces are close to normally distributed. To see whether these measures of competitive forces are correlated with each other, we present correlations matrices in Table 3. Panel A reports the correlations between industry level variables for the overall sample, where we use Compustat HHI as a measure of industry concentration (4,035 industry-year observations). Panel B reports the correlations matrix for the manufacturing industries only, where we use Census HHI as a measure of industry concentration (2,311 industry-year observations). In general, there are significant correlations among these variables, which may raise multicollinearity issues if we use them in the same regression. Therefore, our regression analysis examines the five competitive forces individually. Previous research has examined competitive forces solely on an individual basis; using one aspect of industry structure at a time. The contribution of this paper is that the Porter Five Forces measure allows us to capture multiple aspects of industry structure simultaneously. Thus, the major emphasis in the regression analysis involves those that use the overall Porter's Five Forces variable.

Figure 1 presents the intensity of the competitive forces in Household Audio and Video Equipment industry (SIC code=3651). This industry is in the bottom decile for intensity of threat of existing rivals and threat of new entrants, 6th decile for intensity of threat of substitutes, 4th decile for intensity of customer power, and 6th decile for intensity of supplier power. Therefore, its overall Porter's Five Forces measure is low at 18 out of 50 (the median value of the overall Porter's Five Forces measure is 26 out of 50). Figure 2 presents the intensity of the competitive forces in Printing Trades Machinery and Equipment industry (SIC code=3555). This industry is in the 6th decile for intensity of threat of existing rivals, 8th decile for intensity of threat of new entrants, 7th decile for intensity of threat of substitutes, 6th decile for intensity of customer power, and 9th decile for intensity of supplier power. As a result, its overall Porter's Five Forces measure is high at 36 out of 50.

Examining the firm efficiency in these two industries, we find that the average efficiency score for firms in the Household Audio and Video Equipment industry is 0.77 and the average efficiency score for firms in the Printing Trades Machinery and Equipment industry is 0.85. The difference is significant at 5%. Thus, firms in the Printing Trades Machinery and Equipment industry use resources significantly more efficiently than those in the Household Audio and Video Equipment industry. This comparison suggests that, consistent with Hypothesis 1, firms in more competitive industries (Printing Trades Machinery and Equipment) are more efficient than those in less competitive industries (Household Audio and Video Equipment). Further, an examination of the extent of strategic interaction in these two industries reveals that the average Abs(CSM) measure for the Household Audio and Video Equipment industry is 0.12 and for the Printing Trades Machinery and Equipment industry is 0.10. The difference is significant at 10%. CSM measures the cross-partial derivative of a firm's profit with respect to its own and its rivals' sales. This suggests that, consistent with Hypothesis 2, the level of strategic interaction in an industry may also play a role in how firms structure their use of resources.

To see if we can generalize these statements, in Table 4 we show a cross-tabulation of firm efficiency using the intensity of the Porter's Five Forces (P5F) and the extent of the strategic interactions (Abs(CSM)). Values shaded in green have the highest efficiency scores (and the darker the shading the more efficient the industry firms), while those shaded in red have the lowest efficiency scores (and the darker the shading the less efficient the industry firms). The key take away from this table is that firms in industries with high intensity of Porter's Five Forces and low levels of strategic interactions (in the top right corner) on average have the highest efficiency scores. Firms in industries with low intensity of Porter's Five Forces and high levels of strategic interactions (the bottom left corner) on average have the lowest efficiency scores. These results are particularly strong for firms in manufacturing industries (Panel B). While interesting, these observations are based on univariate analysis, which do not control for various firm-level characteristics that might influence firm efficiency or other unobserved time-varying effects.

4.2. Main Regression Analysis

To test the relation between the product market competition and firm efficiency in a multivariate setting, we estimate regressions of the following type:

$$Efficiency_{i,t} = \beta_0 + \beta_1 Competition_{j,t} + \beta_2 Controls_{i,t} + u_j + v_t + \varepsilon_{i,t}, \qquad (6)$$

where *i*, *j*, and *t* are firm, industry, and time subscripts, respectively. As measures of product market competition, we use intensity scores for each of the Porter's Five Forces, as well as the overall intensity of Porter's Five Forces (the sum of the five intensity scores). Since the dependent variable (firm efficiency) ranges from zero to one, we also scale intensity scores by the maximum value for each year (so they also range from zero to one, rather than 1 to 10).

Control variables include firm characteristics size (log(Assets)), fixed assets ratio (PP&E/Assets), Leverage, ROA, and Market-to-Book. Standard errors are clustered by firm and are robust to heteroskedasticity.

Table 5 presents results from regressions of firm efficiency on our product market competition measures. All regressions in the table show that firm characteristics matter in explaining firm efficiency. In particular, larger firms, firms with a lower proportion of fixed assets, firms with more leverage, better financial performance (higher ROA), and higher growth opportunities (higher market-to-book) have higher efficiency scores. Regressions 1 through 5 show the effects of Porter's Five Forces individually. Based on Hypothesis 1, we expect these forces to have a positive effect on firm efficiency. We see the expected positive sign on the threat of new entrants (coefficient = 0.022), threat of substitutes (coefficient = 0.011), and bargaining power of suppliers (coefficient = 0.038). However, threat of existing industry rivals (coefficient = -0.019) and bargaining power of customers (coefficient = -0.017) have a negative and significant effect on firm efficiency. These negative signs persist in regression 6 where all competitive forces are included. While regression 6 has the advantage of controlling for other competitive forces in the industry, it also suffers from potential multicollinearity problem. Results from regression 7 reveal that the combined effect of Porter's Five Forces on firm efficiency is weakly positive (coefficient = 0.022, significant at 10%).

To test whether the extent of strategic interaction among firms in an industry has any effect on the relationship between product market competition and firm efficiency (Hypothesis 2), we divide the sample into two subsamples based on the absolute value of CSM: those with an Abs(CSM) above the sample median and those with an Abs(CSM) below the sample median. A high value for Abs(CSM) indicates a high level of strategic interaction regardless of the type of strategic interaction (i.e., whether firms compete in strategic complements or substitutes). A low value for Abs(CSM) indicates a low level of strategic interaction among the firms in the industry.

Table 6 presents results from regressions for these two subsamples. Comparing the results of regressions 1 and 2 we see that the extent of strategic interaction has a significant impact on the relationship between competitive forces in the industry and firm efficiency. Threat of existing rivals has opposite effects on firm efficiency in these subsamples: negative and significant effect in the high strategic interaction subsample (coefficient = -0.037) and positive and significant effect on the low strategic interaction subsample (coefficient = 0.013). Thus, we get the expected positive relation in the low strategic interaction subsample, but an unexpected negative relation in the low strategic interaction subsample. Similarly, the negative sign on the customer power variable in Table 5 seems to be driven by the high strategic interaction subsample (coefficient = -0.041). Both the threat of new entrants and bargaining power of supplier variables have the expected positive sign in regressions 1 and 2. However, due to the significant correlations we observed in Table 3, we rely more on aggregated industry level variables horizontal competition (the sum of the intensity of customer power and supplier power), vertical competition (the sum of the intensity of the threat of existing rivals, threat of new entrants, and threat of substitute products), and the overall intensity of Porter's Five Forces. The correlation between the horizontal and vertical competition variables is 0.02.

Results from regressions 3 through 6 reveal that the expected positive sign on product market competition is only present in the subsample with a low level of strategic interaction (e.g., coefficient on Porter's Five Force = 0.067 in regression 6). In contrast, in the subsample with a high level of strategic interaction, we observe negative and significant signs on the product market competition (e.g., coefficient on Porter's Five Force = -0.055 in regression 5). That is, consistent with Hypothesis 2, product market competition seems to provide incentives for the efficient use of firm resources only when rivals are not expected to react aggressively to the actions of the competing firm. When firms compete in industries with a high level of strategic interaction, they are forced to react constantly to the actions of rivals. This hinders the firm's ability to focus on efficiency.

As a robustness test, we partition the overall sample into terciles based on Abs(CSM), and look at the effect of product market competition on firm efficiency in the top and bottom terciles. Results not only confirm the findings in Table 6, but get stronger. The coefficient on the overall intensity of Porter's Five Forces in the high strategic interaction subsample (top tercile based on Abs(CSM)) is -0.076 (significant at the 1%). In contrast, the coefficient on Porter's Five Forces in the low strategic interaction subsample (bottom tercile based on Abs(CSM)) is 0.071 (significant at the 1%).

4.3. Subsample Analysis for the Manufacturing Industries

The analysis so far uses Compustat HHI as the measure of industry concentration (PF1 Rivals). However, as mentioned above, Compustat HHI may lead to incorrect conclusions due to the omission of private firms from the computation of HHI. To correct for this, many recent studies use Census-based HHI as a measure of industry concentration (e.g., Hoberg and Phillips, 2010a; Giroud and Mueller, 2010, 2011; Chhaochharia et al., 2012; Valta, 2012). Census of Manufactures publications report concentration ratios for public and private firms in hundreds of industries in the manufacturing sector. Accordingly, we narrow down our sample, in Table 7, to include just manufacturing industries (SIC codes 2000-3999) and use Census-based HHI.

Comparing the results from regressions in Table 7 to those in Table 5 reveals some similarities as well as differences. Most notable is the difference for the effect of threat of industry rivals (PF1 Rivals, which is computed from Census HHI) on firm efficiency and now has the expected positive sign (coefficient = 0.026). Karuna (2007) reports a similar reversal of signs, where Compustat HHI has a positive and significant effect on managerial incentives, and Census HHI has a negative and significant effect. We explore whether the positive relationship between threat of industry rivals and firm efficiency is specific to manufacturing firms by separating the Compustat HHI sample into manufacturing and non-manufacturing industries, and rerunning regressions. The untabulated results show that the relationship between threat of industry rivals and firm efficiency is negative if we use Compustat HHI and positive if we use Census HHI. Therefore, the reversal of sign is not due to the difference in sample, but rather due to the difference in number of firms included in the concentration measure (all industries versus manufacturing industries only). This positive relationship between threat of industry rivals and firm efficiency is consistent with Caves and Barton (1990). While coefficients on customer power (-0.053) and supplier power (0.024) are similar to those in Table 5, the coefficients on threat of new entrants (0.004) and threat of substitute products (-0.001) are no longer significant, resulting in an insignificant coefficient on the overall intensity of Porter's Five Forces.

In Table 8 we partition the manufacturing industry sample into two subsamples based on the median value of Abs(CSM). Comparing the results from regressions in Table 8 to those in Table 6 again reveals some similarities and some differences. Unlike Table 6, Table 8 shows that threat of industry rivals has a positive and significant effect on firm efficiency regardless of the level of strategic interaction (e.g., coefficient on PF1 Rivals Census = 0.037 in regression 1 and 0.020 in regression 2). Like Table 6, Table 8 shows threat of substitute products and bargaining power of customers have negative and significant effect on firm efficiency in subsample with a high level of strategic interaction (coefficients are -0.027 and -0.060, respectively, in regression 1). In contrast to Table 6, in the subsample with a low level of strategic interaction (regression 2 in Table 8), bargaining power of customers has a negative and significant effect on firm efficiency (coefficient = -0.040). As for the overall intensity of Porter's Five Forces, we see the expected positive and significant effect on firm efficiency, but only in the subsample with a low level of strategic interaction (coefficient = 0.039 in regression 6). The relation is negative in the subsample with a high level of strategic interaction (coefficient = -0.055 in regression 5). These are consistent with results reported in Table 6 for the overall sample which include manufacturing and non-manufacturing industries.

As a robustness test, we partition the manufacturing sample into terciles based on Abs(CSM) to look at the effect of product market competition on firm efficiency in the top and bottom terciles. We again find that the coefficient on Porter's Five Forces is positive (0.037) and significant at the 5% level in the bottom tercile (in terms of Abs(CSM)). However, the coefficient on this variable in the top tercile (in terms of Abs(CSM)) is no longer significant.

4.4. Robustness Tests

Because strategic interaction among firms plays an integral part in determining conditions under which product market competition affects firm efficiency, we conduct robustness tests by using an alternative measure of strategic interaction. In particular, we use a product market competition measure, developed by Hoberg et al. (2014). As discussed earlier, Hoberg et al. (2014) examine firms' business descriptions provided in 10K's and measure the change in a firm's 'product space' due to moves made by competitors in the firm's product markets. They call this "product market fluidity." Fluidity is greater when a firm's business description (as listed in 10K's) overlaps with rivals'. Since the focus on rivals is a distinguishing feature of fluidity, it is similar in spirit to the competitive strategy measure (CSM).

We use product market fluidity (PMF), i.e., product market competition, as an alternative measure to strategic interaction (CSM). The product market competition variable is downloaded from http://alex2.umd.edu/industrydata/industryconcen.htm. Industry average levels of product market fluidity are calculated by industry and year (similar to the way we calculated industry average CSM). The correlation between industry average product market fluidity and overall intensity of Porter's Five Forces is -0.35 and the correlation between the industry average product market fluidity and Abs(CSM) is 0.08.

Hoberg et al.'s (2014) sample period begins in 1997. Replicating this time period, our sample size drops from 57,926 firm-year observations to 35,887 firm-year observations. With this data set, we rerun our main regressions in Table 5, as well as the regressions using subsamples based on the extent of strategic interaction in Table 6. Tables 9 and 10 report results from these regressions. Regression coefficients reported in Table 9 are very similar to those in Table 5 in that threat of industry rivals and customer power are negative and significant (coefficients are -0.027 and -0.016, respectively), and coefficients on threat of new entrants and threat of substitute products are positive and significant (coefficients are 0.022 and 0.013, respectively). The effect of overall intensity of Porter's Five Forces on firm efficiency in this sample is insignificant (coefficient is 0.002).

In Table 10 we partition the sample based on the median value of product market fluidity. As in Table 6, overall intensity of Porter's Five Forces has a positive and significant effect on firm efficiency in a subsample with a low level of strategic interaction (below median PMF, coefficient = 0.087) and a negative and significant effect on firm efficiency in a subsample with a high level of strategic interaction (above median PMF, coefficient = -0.156). Partitioning the sample into terciles based on the PMF produces similar results. The untabulated results show the coefficient on the overall intensity of Porter's Five Forces is positive (0.048) and significant at 1% for the bottom tercile (lowest level of PMF) and negative (-0.180) and significant at 1% for the top tercile (highest level of PMF). Finally, regressions run on a subsample of manufacturing industries (using Census HHI as a measure of industry concentration) produces identical results as well. Both quantile and tercile partitions reveal that the product market competition has a positive and significant effect on firm efficiency when level of strategic interaction is low and a negative and significant effect on firm efficiency when level of strategic interaction is high.

5. Conclusions

This paper empirically examines whether product market competition plays a significant role in providing incentives for the efficient use of firm resources by employing multidimensional measures of product market competition and firm efficiency. While previous studies have examined this issue using one-dimensional measures such as ROA and ROE, we evaluate firm efficiency using a frontier efficiency methodology. Further, previous studies that examine product market competition predominantly use only one aspect of industry structure: competition among industry rivals, which is often measured by industry concentration. We capture multiple aspects of industry structure using Porter's Five Forces: rivalry among existing competitors, bargaining power of customers, bargaining power of suppliers, threat of new entrants, and threat of substitute products. Aditionally, to examine how strategic decisions affect the competitive environment and therefore the efficient use of firm resources, we capture the responsiveness of a firm's profits to changes in its competitors' action by computing a competitive strategy measure (CSM).

We find that the combined effect of Porter's Five Forces on firm efficiency is weak at best. However, when we introduce strategic dynamics to the analysis, we find a positive and significant relationship between the intensity of Porter's Five Forces and firm efficiency in industries with a low level of strategic interaction and a negative and significant relationship in industries with a high level of strategic interaction. These results are robust in the subsample of manufacturing industries and using alternate measures of industry concentration.

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Figure 1
Intensity of Competitive Forces in
Household Audio and Video Equipment Industry (SIC = 3651)

This figure presents the intensity of the competitive forces in Household Audio and Video Equipment industry (SIC code = 3651). *PF1 Rivals* is an intensity score based on *Compustat HHI* (10 for the bottom decile through 1 for the top decile). *PF2 New Entrants* is an intensity score based on *ENTCOST* (a measure of entry costs; 10 for the bottom decile through 1 for the top decile). *PF3 Substitutes* is an intensity score based on *DIFF* (a product differentiation measure; 10 for the bottom decile through 1 for the top decile). *PF4 Customer Power* is an intensity score based on the concentration of customer industries (10 for the top decile through 1 for the bottom decile). *PF5 Supplier Power* is an intensity score based on the concentration of supplier industries (10 for the top decile through 1 for the bottom decile).

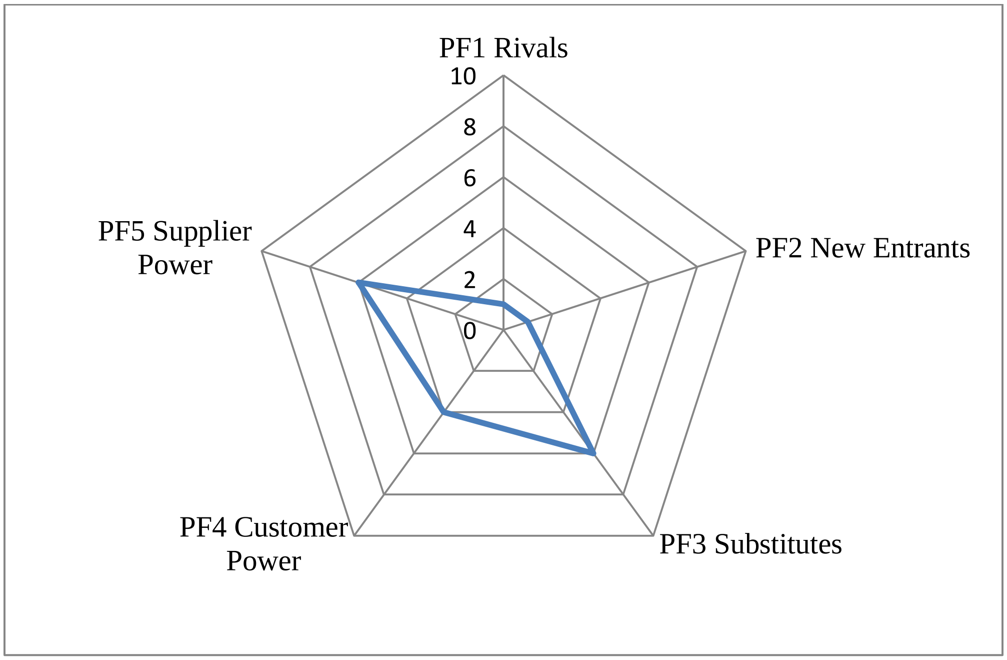

Figure 2
Intensity of Competitive Forces in
Printing Trades Machinery and Equipment Industry (SIC = 3555)

This figure presents the intensity of the competitive forces in Printing Trades Machinery and Equipment industry (SIC code = 3555). *PF1 Rivals* is an intensity score based on *Compustat HHI* (10 for the bottom decile through 1 for the top decile). *PF2 New Entrants* is an intensity score based on *ENTCOST* (a measure of entry costs; 10 for the bottom decile through 1 for the top decile). *PF3 Substitutes* is an intensity score based on *DIFF* (a product differentiation measure; 10 for the bottom decile through 1 for the top decile). *PF4 Customer Power* is an intensity score based on the concentration of customer industries (10 for the top decile through 1 for the bottom decile). *PF5 Supplier Power* is an intensity score based on the concentration of supplier industries (10 for the top decile through 1 for the bottom decile).

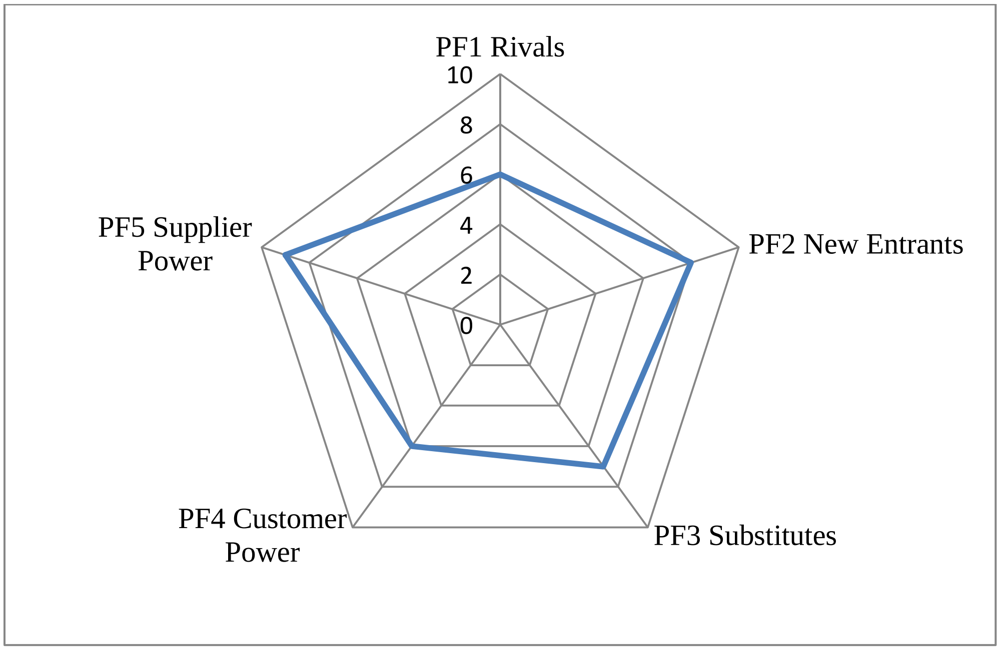

Table 1

Descriptive Statistics: Firm-level Variables

This table reports descriptive statistics of the firm-level variables for sample firms in Compustat during fiscal years 1988-2010. All input and output quantities are in millions of dollars, and are constructed as in Demerjian et al. (2012). Seven inputs are used: (1) net property, plant and equipment (PP&E); (2) capitalized operating leases, which is calculated as the discounted (at 10%) present value of five years of lease payments (Leases); (3) five-year capitalized value of research and development expenses (R&D); (4) purchased goodwill, which is calculated as the premium paid over the fair value of an acquisition (Goodwill); (5) other acquired and capitalized intangibles (Intangibles); (6) cost of goods sold (COGS); and (7) selling, general, and administrative costs (SG&A). Output is net sales of the firm (Revenue). A firm is classified as fully efficient if it lies on the production best-practice frontier of firms (Efficiency = 1) and inefficient if its outputs can be produced more efficiently by another set of firms (0 < Efficiency < 1). Efficiency is measured separately by year and industry. Firm-level control variables include log of market value of assets (Log(Market Value of Total Assets)), fixed asset ratio (PP&E/Book Value of Total Assets), market value leverage (Total Debt/Market Value of Assets), ROA (Operating Income before Depreciation /Book Value of Total Assets), and market-to-book ratio (Market Value of Total Assets/Book Value of Total Assets).

Variable	N	Mean	Median	Stdev	Min	Max
Panel A – Input and Output Variables (millions of $)						
PP&E	57,926	535.15	15.75	2633.03	0.00	67,378.76
Leases	57,926	45.03	2.57	177.62	0.00	2,679.12
R&D	57,926	63.08	0.00	349.49	0.00	7,532.43
Goodwill	57,926	101.50	0.00	595.15	0.00	14,958.00
Intangibles	57,926	38.98	0.00	293.72	0.00	7,996.80
COGS	57,926	672.03	42.21	2713.40	0.02	50,370.00
SG&A	57,926	180.63	15.77	754.12	0.00	14,120.87
Revenue	57,926	1,032.59	73.33	4012.79	0.02	78,025.00
Panel B – Efficiency and Control Variables						
Efficiency	57,926	0.72	0.79	0.24	0.00	1.00
Assets (millions of $)	57,926	2,874.87	149.62	15,847.67	0.03	637,207.70
Log(Assets)	57,926	5.17	5.01	2.32	-3.62	13.36
PP&E/Assets (%)	57,926	26.95	18.60	24.10	0.33	91.14
Leverage (%)	57,926	16.20	9.59	18.49	0.00	99.23
ROA (%)	57,926	-6.02	9.04	54.72	-365.61	43.96
Market-to-Book (X)	57,926	2.63	1.57	3.57	0.54	27.16

Table 2
Descriptive Statistics: Industry-level Variables

This table reports descriptive statistics for industry-level variables for 1988-2010. The data come from Compustat, Census of Manufactures, and *Use* table of the benchmark input-output accounts from Bureau of Economic Analysis. All variables are calculated at the 4-digit SIC code level. Panel A reports descriptive statistics for the raw industry variables and Panel B reports descriptive statistics for the intensity scores based on raw industry variables. *HHI* is the Herfindahl-Hirschman index of an industry, calculated by adding the squares of the sales market shares of all the firms in an industry that have sales data on Compustat. *HHI-Census* is the Herfindahl-Hirschman index of an industry calculated by the Census of Manufactures as the sum of the squares of the individual company market shares of all the companies in an industry or the fifty largest companies in the industry, whichever is lower. *CSM* is a competitive strategy measure adapted from Lyandres (2006). It is the cross-partial derivative of a firm's profit with respect to its strategy and its rivals strategy, computed using quarterly data from Compustat. *Abs(CSM)* is the absolute value of the competitive strategy measure, proxying for the extent of strategic interaction. *ENTCOST* is a measure of entry costs based on Karuna (2007), calculated as the log of the weighted average gross value of property, plant, and equipment for firms for which this is the primary industry, weighted by each firm's market share in this industry. *DIFF* is a product differentiation measure also adapted from Karuna (2007), calculated as industry sales divided by industry operating costs. *Customer (Supplier) Power* variables are calculated as in Kale and Shahrur (2007) where customer (supplier) power is proxied by the concentration of customer (supplier) industries. Intensity scores indicate which decile an industry belongs to in terms of a specific competitive force. For example, to capture the intensity of the threat of existing rivals, we assign a score of 10 to the industries in the bottom decile of *HHI* variable (i.e., least concentrated implies most competition from industry rivals), 9 to the second decile of *HHI* variable, 8 to the third decile, and so on. An all-encompassing single measure of product market competition is sum of these five intensity scores.

Variable	N	Mean	Median	Stdev	Min	Max
Panel A – Raw Industry Variables						
HHI	4,035	0.34	0.29	0.22	0.03	1.00
HHI - Census	2,311	0.07	0.06	0.06	0.00	0.30
CSM	4,035	-0.03	-0.02	0.19	-0.99	0.95
Abs(CSM)	4,035	0.14	0.10	0.13	0.00	0.99
ENTCOST	4,035	6.74	6.64	1.93	0.23	12.18
DIFF	4,035	1.58	1.12	2.47	0.90	31.83
Customer Power	4,035	0.11	0.08	0.12	0.00	0.93
Supplier Power	4,035	0.12	0.10	0.07	0.01	0.79
Panel B – Intensity Scores						
PF1 Rivals	4,035	5.77	6.00	2.89	1.00	10.00
PF1 Rivals - Census	2,311	5.71	6.00	2.93	1.00	10.00
PF2 Entrants	4,035	5.46	5.00	2.89	1.00	10.00
PF3 Substitutes	4,035	5.38	5.00	2.88	1.00	10.00
PF4 Customer Power	4,035	5.03	5.00	2.65	1.00	10.00
PF5 Supplier Power	4,035	4.62	4.00	2.91	1.00	10.00
Porters Five Forces	4,035	26.26	26.00	6.44	9.00	49.00

Table 3
Correlation Matrices of Industry-level Variables

The table presents correlation matrices for industry-level variables for 1988-2010. Panel A reports correlations between industry level variables for the overall sample, which includes all industries except financials and utilities. Panel B reports correlations between industry level variables for the manufacturing subsample (SIC codes 2000-3999). The data come from Compustat, Census of Manufactures, and *Use* table of the benchmark input-output accounts from Bureau of Economic Analysis. All variables are calculated at the 4-digit SIC code level. *PF1 Rivals* is an intensity score based on *Compustat HHI* (10 for the bottom decile through 1 for the top decile). *PF2 New Entrants* is an intensity score based on *ENTCOST* (a measure of entry costs; 10 for the bottom decile through 1 for the top decile). *PF3 Substitutes* is an intensity score based on *DIFF* (a product differentiation measure; 10 for the bottom decile through 1 for the top decile). *PF4 Customer Power* is an intensity score based on the concentration of customer industries (10 for the top decile through 1 for the bottom decile). *PF5 Supplier Power* is an intensity score based on the concentration of supplier industries (10 for the top decile through 1 for the bottom decile). *Porter's Five Forces* is an all-encompassing single measure of product market competition, which is the sum of the five intensity scores. *CSM* is a competitive strategy measure, which is the cross-partial derivative of a firm's value with respect to its strategy and its' rivals strategy.

Panel A – All industries	PF1 Rivals	PF2 New Entrants	PF3 Substitutes	PF4 Customer Power	PF5 Supplier Power	Porter's Five Forces	Abs(CSM)
PF1 Rivals	1.0000						
PF2 New Entrants	-0.1736	1.0000					
PF3 Substitutes	-0.2421	0.3425	1.0000				
PF4 Customer Power	-0.0387	-0.0014	0.0802	1.0000			
PF5 Supplier Power	-0.1895	-0.0210	0.2174	0.1029	1.0000		
Porter's Five Forces	0.1517	0.5002	0.6046	0.4632	0.4931	1.0000	
Abs(CSM)	-0.1145	0.0491	0.0601	-0.0235	0.0363	-0.0156	1.0000

Panel B – Manufacturing industries	PF1 Rivals Census	PF2 New Entrants	PF3 Substitutes	PF4 Customer Power	PF5 Supplier Power	Porter's Five Forces	Abs(CSM)
PF1 Rivals Census	1.0000						
PF2 New Entrants	0.3501	1.0000					
PF3 Substitutes	0.0895	0.3190	1.0000				
PF4 Customer Power	0.0845	-0.1154	0.0520	1.0000			
PF5 Supplier Power	0.0670	0.0520	0.2226	0.0079	1.0000		
Porter's Five Forces	0.2618	0.4817	0.5884	0.4329	0.4579	1.0000	
Abs(CSM)	0.0338	0.0397	0.0244	-0.0530	0.0048	-0.0450	1.0000

Table 4

Univariate Analysis of Firm Efficiency Using the Intensity of Porter's Five Forces and Extent of Strategic Interaction

This table presents average firm efficiency for subsamples based on the overall intensity of Porter's Five Forces and the absolute value of CSM for the period 1988-2010. Panel A reports efficiency scores for the overall sample, which includes firms in all industries except financials and utilities. Panel B reports efficiency scores for firms in the manufacturing subsample (SIC codes 2000-3999). The data come from Compustat, Census of Manufactures, and *Use* table of the benchmark input-output accounts from Bureau of Economic Analysis. A firm is classified as fully efficient if it lies on the production best-practice frontier of firms (Efficiency = 1) and inefficient if its outputs can be produced more efficiently by another set of firms (0 < Efficiency < 1). Efficiency is measured separately by year and industry. *P5F D1* refers to the bottom decile for the overall intensity of Porter's Five Forces; *P5F D2* refers to the second decile for the overall intensity of Porter's Five Forces; etc. Similarly, *Abs(CSM) D1* through *Abs(CSM) D10* refers to deciles for the absolute value of CSM measure.

Panel A – All industries (except financials and utilities)

	P5F D1	P5F D2	P5F D3	P5F D4	P5F D5	P5F D6	P5F D7	P5F D8	P5F D9	P5F D10	Total
Abs(CSM) D1	0.7285	0.7540	0.7894	0.7835	0.7171	0.7943	0.7855	0.7974	0.7469	0.7998	0.7648
Abs(CSM) D2	0.6658	0.7900	0.7616	0.7588	0.7599	0.7653	0.7813	0.6817	0.7878	0.8347	0.7598
Abs(CSM) D3	0.7744	0.6608	0.7206	0.6794	0.7730	0.7541	0.7890	0.6693	0.7349	0.7913	0.7339
Abs(CSM) D4	0.7498	0.6855	0.7339	0.6722	0.6998	0.6743	0.7998	0.7545	0.7555	0.8107	0.7305
Abs(CSM) D5	0.6849	0.7206	0.7638	0.7836	0.6128	0.7425	0.7533	0.7237	0.7672	0.8144	0.7350
Abs(CSM) D6	0.7315	0.7366	0.6162	0.6872	0.6543	0.7680	0.7770	0.7525	0.7899	0.8160	0.7234
Abs(CSM) D7	0.7124	0.6566	0.6558	0.6714	0.5766	0.7828	0.7709	0.7499	0.7209	0.7395	0.6887
Abs(CSM) D8	0.7956	0.6440	0.6696	0.5931	0.6959	0.6898	0.6553	0.6183	0.7936	0.8367	0.6884
Abs(CSM) D9	0.6062	0.5984	0.6383	0.5944	0.6550	0.7490	0.5515	0.7347	0.6787	0.7804	0.6421
Abs(CSM) D10	0.6461	0.6174	0.5252	0.7202	0.7682	0.7863	0.7200	0.7538	0.7514	0.8083	0.6963
Total	0.6969	0.6774	0.6802	0.6786	0.6743	0.7431	0.7389	0.7138	0.7520	0.8022	0.7164

Panel B – Manufacturing industries

	P5F D1	P5F D2	P5F D3	P5F D4	P5F D5	P5F D6	P5F D7	P5F D8	P5F D9	P5F D10	Total
Abs(CSM) D1	0.7842	0.8563	0.8379	0.7077	0.7505	0.8347	0.8025	0.8603	0.8677	0.8439	0.8103
Abs(CSM) D2	0.5285	0.8045	0.6663	0.7493	0.7533	0.7143	0.8423	0.8124	0.8748	0.8342	0.7503
Abs(CSM) D3	0.7000	0.5915	0.7131	0.5405	0.7848	0.7964	0.7856	0.8424	0.8644	0.8787	0.7640
Abs(CSM) D4	0.5937	0.4902	0.7116	0.7412	0.7733	0.8580	0.8139	0.7985	0.8502	0.8686	0.7630
Abs(CSM) D5	0.8018	0.5762	0.7249	0.6155	0.7529	0.8138	0.8511	0.8129	0.7960	0.8570	0.7544
Abs(CSM) D6	0.5196	0.5827	0.6985	0.7630	0.7693	0.7400	0.7465	0.7675	0.8616	0.8491	0.7237
Abs(CSM) D7	0.5229	0.5055	0.7629	0.7026	0.6703	0.7216	0.7229	0.7669	0.8304	0.8709	0.6834
Abs(CSM) D8	0.5397	0.7557	0.6346	0.7194	0.8040	0.7755	0.7899	0.7993	0.8656	0.8427	0.7290
Abs(CSM) D9	0.4824	0.6113	0.7576	0.6735	0.7566	0.5412	0.7230	0.6653	0.8402	0.8838	0.6704
Abs(CSM) D10	0.5316	0.5302	0.6279	0.7771	0.7737	0.7437	0.7573	0.7813	0.8406	0.8592	0.7267
Total	0.5658	0.6022	0.6954	0.6916	0.7577	0.7535	0.7797	0.7954	0.8472	0.8565	0.7376

Table 5

Regressions of Firm Efficiency on Product Market Competition

This table reports results of pooled OLS regressions on firm efficiency for 1988-2010. The data come from Compustat, Census of Manufactures, and the *Use* table of benchmark input-output accounts from Bureau of Economic Analysis. *Log(Assets)* is the natural logarithm of market value of assets, *PP&E/Assets* is the ratio of net property, plant, and equipment to book value of total assets, *Leverage* is ratio of total debt to market value of assets, *ROA* is operating income before depreciation divided by book value of total assets, and *Market-to-Book* is market value of assets divided by book value of assets. *PF1 Rivals* is an intensity score based on *Compustat HHI* (10 for the bottom decile through 1 for the top decile). *PF2 New Entrants* is an intensity score based on *ENTCOST* (a measure of entry costs; 10 for the bottom decile through 1 for the top decile). *PF3 Substitutes* is an intensity score based on *DIFF* (a product differentiation measure; 10 for the bottom decile through 1 for the top decile). *PF4 Customer Power* is an intensity score based on the concentration of customer industries (10 for the top decile through 1 for the bottom decile). *PF5 Supplier Power* is an intensity score based on the concentration of supplier industries (10 for the top decile through 1 for the bottom decile). Since the dependent variable (firm efficiency) ranges from zero to one, we also scale intensity scores by the maximum value for each year (so they also range from zero to one). Year dummies and Fama and French (1997) industry dummies are included in the regressions, but are not reported. Standard errors are clustered at the firm level, and robust to heteroskedasticity. * $p<0.10$, ** $p<0.05$, *** $p<0.01$

	(1) Efficiency	(2) Efficiency	(3) Efficiency	(4) Efficiency	(5) Efficiency	(6) Efficiency	(7) Efficiency
Log(Assets)	0.012***	0.012***	0.012***	0.012***	0.011***	0.012***	0.012***
PP&E/Assets	-0.081***	-0.079***	-0.081***	-0.080***	-0.080***	-0.075***	-0.081***
Leverage	0.015**	0.015**	0.016**	0.016**	0.015**	0.015**	0.016**
ROA	0.089***	0.088***	0.089***	0.089***	0.089***	0.089***	0.089***
Market-to-Book	0.009***	0.009***	0.009***	0.009***	0.009***	0.009***	0.009***
PF1 Rivals	-0.019***					-0.015***	
PF2 New Entrants		0.022***				0.020***	
PF3 Substitutes			0.011**			0.002	
PF4 Customer Power				-0.017**		-0.016**	
PF5 Supplier Power					0.038***	0.031***	
Porter's Five Forces							0.022*
Constant	0.596***	0.567***	0.575***	0.595***	0.579***	0.581***	0.570***
Adjusted R^2	0.48	0.48	0.48	0.48	0.48	0.48	0.48
No. observations	57926	57926	57926	57926	57926	57926	57926

Table 6
Regressions for Above and Below Median Abs(CSM) Subsamples

This table reports the results of pooled OLS regressions on firm efficiency for 1988-2010. Columns 1, 3, and 5 report results from OLS regressions on a subsample of firms with an Abs(CSM) above the sample median (i.e., high level of strategic interaction). Columns 2, 4, and 6 report results from OLS regressions on a subsample of firms with an Abs(CSM) below the sample median (i.e., low level of strategic interaction). The data come from Compustat, Census of Manufactures, and the *Use* table of benchmark input-output accounts from Bureau of Economic Analysis. *Log(Assets)* is the natural logarithm of market value of assets, *PP&E/Assets* is the ratio of net property, plant, and equipment to book value of total assets, *Leverage* is ratio of total debt to market value of assets, *ROA* is operating income before depreciation divided by book value of total assets, and *Market-to-Book* is market value of assets divided by book value of assets. *PF1 Rivals* is an intensity score based on *Compustat HHI* (10 for the bottom decile through 1 for the top decile). *PF2 New Entrants* is an intensity score based on *ENTCOST* (a measure of entry costs; 10 for the bottom decile through 1 for the top decile). *PF3 Substitutes* is an intensity score based on *DIFF* (a product differentiation measure; 10 for the bottom decile through 1 for the top decile). *PF4 Customer Power* is an intensity score based on the concentration of customer industries (10 for the top decile through 1 for the bottom decile). *PF5 Supplier Power* is an intensity score based on the concentration of supplier industries (10 for the top decile through 1 for the bottom decile). Since the dependent variable (firm efficiency) ranges from zero to one, we also scale intensity scores by the maximum value for each year (so they also range from zero to one). Year dummies and Fama and French (1997) industry dummies are included in the regressions, but are not reported. Standard errors are clustered at the firm level and are robust to heteroskedasticity. * p<0.10, ** p<0.05, *** p<0.01.

	(1) Efficiency	(2) Efficiency	(3) Efficiency	(4) Efficiency	(5) Efficiency	(6) Efficiency
	Above Median Abs(CSM)	Below Median Abs(CSM)	Above Median Abs(CSM)	Below Median Abs(CSM)	Above Median Abs(CSM)	Below Median Abs(CSM)
Log(Assets)	0.011***	0.013***	0.010***	0.013***	0.010***	0.013***
PP&E/Assets	-0.063***	-0.089***	-0.071***	-0.093***	-0.070***	-0.093***
Leverage	0.021**	0.003	0.022**	0.003	0.022**	0.003
ROA	0.090***	0.087***	0.091***	0.086***	0.091***	0.086***
Market-to-Book	0.009***	0.008***	0.009***	0.008***	0.009***	0.008***
PF1 Rivals	-0.037***	0.013**				
PF2 New Entrants	0.012*	0.018***				
PF3 Substitutes	-0.021***	0.016***				
PF4 Customer Power	-0.041***	-0.011				
PF5 Supplier Power	0.020**	0.039***				
Horizontal Comp			-0.035***	0.045***		
Vertical Comp			-0.023*	0.026**		
Porter's Five Forces					-0.055***	0.067***
Constant	1.034***	0.906***	1.012***	0.901***	1.012***	0.903***
Adjusted R^2	0.48	0.47	0.48	0.47	0.48	0.47
No. observations	28967	28959	28967	28959	28967	28959

Table 7
Regressions for Manufacturing Industries

This table reports results of pooled OLS regressions on firm efficiency for 1988-2010, for a subsample that consists of manufacturing industries (SIC codes 2000-3999). The data come from Compustat, Census of Manufactures, and the *Use* table of benchmark input-output accounts from Bureau of Economic Analysis. *Log(Assets)* is the natural logarithm of market value of assets, *PP&E/Assets* is the ratio of net property, plant, and equipment to book value of total assets, *Leverage* is ratio of total debt to market value of assets, *ROA* is operating income before depreciation divided by book value of total assets, and *Market-to-Book* is market value of assets divided by book value of assets. *PF1 Rivals* is an intensity score based on *Compustat HHI* (10 for the bottom decile through 1 for the top decile). *PF2 New Entrants* is an intensity score based on *ENTCOST* (a measure of entry costs; 10 for the bottom decile through 1 for the top decile). *PF3 Substitutes* is an intensity score based on *DIFF* (a product differentiation measure; 10 for the bottom decile through 1 for the top decile). *PF4 Customer Power* is an intensity score based on the concentration of customer industries (10 for the top decile through 1 for the bottom decile). *PF5 Supplier Power* is an intensity score based on the concentration of supplier industries (10 for the top decile through 1 for the bottom decile). Since the dependent variable (firm efficiency) ranges from zero to one, we also scale intensity scores by the maximum value for each year (so they also range from zero to one). Year dummies and Fama and French (1997) industry dummies are included in the regressions, but are not reported. Standard errors are clustered at the firm level and are robust to heteroskedasticity. * p<0.10, ** p<0.05, *** p<0.01

	(1) Efficiency	(2) Efficiency	(3) Efficiency	(4) Efficiency	(5) Efficiency	(6) Efficiency	(7) Efficiency
Log(Assets)	0.007***	0.007***	0.007***	0.007***	0.007***	0.007***	0.007***
PP&E/Assets	-0.021*	-0.019	-0.019	-0.006	-0.019	-0.008	-0.018
Leverage	0.044***	0.045***	0.046***	0.046***	0.045***	0.045***	0.046***
ROA	0.109***	0.110***	0.110***	0.110***	0.110***	0.109***	0.110***
Market-to-Book	0.009***	0.009***	0.009***	0.009***	0.009***	0.009***	0.009***
PF1 Rivals Census	0.026***					0.023***	
PF2 New Entrants		0.004				0.002	
PF3 Substitutes			-0.001			-0.008	
PF4 Customer Power				-0.053***		-0.052***	
PF5 Supplier Power					0.024***	0.018**	
P5 Forces Census							-0.011
Constant	0.647***	0.239***	0.668***	0.700***	0.244***	0.276***	0.674***
Adjusted R^2	0.52	0.52	0.52	0.52	0.52	0.52	0.52
No. observations	29066	29066	29066	29066	29066	29066	29066

Table 8
Regressions for Manufacturing Industries: Above and Below Median Abs(CSM) Subsamples

This table reports results of pooled OLS regressions on firm efficiency for 1988-2010, for a subsample that consists of manufacturing industries (SIC codes 2000-3999). Columns 1, 3, and 5 report results from OLS regressions on a subsample of firms with an Abs(CSM) above the sample median (i.e., high level of strategic interaction). Columns 2, 4, and 6 report results from OLS regressions on a subsample of firms with an Abs(CSM) below the sample median (i.e., low level of strategic interaction). The data come from Compustat, Census of Manufactures, and the *Use* table of benchmark input-output accounts from Bureau of Economic Analysis. *Log(Assets)* is the natural logarithm of market value of assets, *PP&E/Assets* is the ratio of net property, plant, and equipment to book value of total assets, *Leverage* is ratio of total debt to market value of assets, *ROA* is operating income before depreciation divided by book value of total assets, and *Market-to-Book* is market value of assets divided by book value of assets. *PF1 Rivals* is an intensity score based on *Compustat HHI* (10 for the bottom decile through 1 for the top decile). *PF2 New Entrants* is an intensity score based on *ENTCOST* (a measure of entry costs; 10 for the bottom decile through 1 for the top decile). *PF3 Substitutes* is an intensity score based on *DIFF* (a product differentiation measure; 10 for the bottom decile through 1 for the top decile). *PF4 Customer Power* is an intensity score based on the concentration of customer industries (10 for the top decile through 1 for the bottom decile). *PF5 Supplier Power* is an intensity score based on the concentration of supplier industries (10 for the top decile through 1 for the bottom decile). Since the dependent variable (firm efficiency) ranges from zero to one, we also scale intensity scores by the maximum value for each year (so they also range from zero to one). Year dummies and Fama and French (1997) industry dummies are included in the regressions, but are not reported. Standard errors are clustered at the firm level and are robust to heteroskedasticity. * p<0.10, ** p<0.05, *** p<0.01.

	(1) Efficiency	(2) Efficiency	(3) Efficiency	(4) Efficiency	(5) Efficiency	(6) Efficiency
	Above Median Abs(CSM)	Below Median Abs(CSM)	Above Median Abs(CSM)	Below Median Abs(CSM)	Above Median Abs(CSM)	Below Median Abs(CSM)
Log(Assets)	0.008***	0.007***	0.008***	0.007***	0.007***	0.007***
PP&E/Assets	0.026	-0.045***	0.026	-0.050***	0.018	-0.055***
Leverage	0.055***	0.034***	0.056***	0.034***	0.057***	0.034***
ROA	0.110***	0.107***	0.110***	0.107***	0.110***	0.108***
Market-to-Book	0.010***	0.009***	0.010***	0.009***	0.010***	0.009***
PF1 Rivals Census	0.037***	0.020**				
PF2 New Entrants	-0.010	0.011				
PF3 Substitutes	-0.027***	0.014				
PF4 Customer Power	-0.060***	-0.040***				
PF5 Supplier Power	-0.001	0.029***				
Horizontal Comp			0.008	0.056***		
Vertical Comp			-0.088***	-0.026*		
P5 Forces Census					-0.055***	0.039**
Constant	0.955***	0.923***	0.982***	0.926***	0.994***	0.925***
Adjusted R^2	0.52	0.52	0.52	0.52	0.52	0.52
No. observations	14536	14530	14536	14530	14536	14530

Table 9

Robustness Tests: Regressions for a Sample where Product Market Fluidity is Available

This table reports results of pooled OLS regressions on firm efficiency for 1997-2010. The sample includes firms for which Hoberg et al.'s (2014) product market competition variable, product market fluidity (PMF) is available. The product market fluidity variable is downloaded from http://alex2.umd.edu/industrydata/industryconcen. htm. The data come from Compustat, Census of Manufactures, and the *Use* table of benchmark input-output accounts from Bureau of Economic Analysis. *Log(Assets)* is the natural logarithm of market value of assets, *PP&E/Assets* is the ratio of net property, plant, and equipment to book value of total assets, *Leverage* is ratio of total debt to market value of assets, *ROA* is operating income before depreciation divided by book value of total assets, and *Market-to-Book* is market value of assets divided by book value of assets. *PF1 Rivals* is an intensity score based on *Compustat HHI* (10 for the bottom decile through 1 for the top decile). *PF2 New Entrants* is an intensity score based on *ENTCOST* (a measure of entry costs; 10 for the bottom decile through 1 for the top decile). *PF3 Substitutes* is an intensity score based on *DIFF* (a product differentiation measure; 10 for the bottom decile through 1 for the top decile). *PF4 Customer Power* is an intensity score based on the concentration of customer industries (10 for the top decile through 1 for the bottom decile). *PF5 Supplier Power* is an intensity score based on the concentration of supplier industries (10 for the top decile through 1 for the bottom decile). Since the dependent variable (firm efficiency) ranges from zero to one, we also scale intensity scores by the maximum value for each year (so they also range from zero to one). Year dummies and Fama and French (1997) industry dummies are included in the regressions, but are not reported. Standard errors are clustered at the firm level and are robust to heteroskedasticity. * p<0.10, ** p<0.05, *** p<0.01

	(1) Efficiency	(2) Efficiency	(3) Efficiency	(4) Efficiency	(5) Efficiency	(6) Efficiency	(7) Efficiency
Log(Assets)	0.009***	0.009***	0.009***	0.009***	0.009***	0.009***	0.009***
PP&E/Assets	-0.080***	-0.080***	-0.081***	-0.080***	-0.082***	-0.076***	-0.082***
Leverage	0.022**	0.023**	0.023***	0.023***	0.023***	0.022**	0.023***
ROA	0.084***	0.084***	0.085***	0.085***	0.085***	0.084***	0.085***
Market-to-Book	0.010***	0.010***	0.010***	0.010***	0.010***	0.010***	0.010***
PF1 Rivals	-0.027***					-0.023***	
PF2 New Entrants		0.022***				0.018**	
PF3 Substitutes			0.013**			0.006	
PF4 Customer Power				-0.016*		-0.018**	
PF5 Supplier Power					0.012	0.001	
Porter's Five Forces							0.002
Constant	0.957***	0.918***	0.922***	0.939***	0.931***	0.944***	0.931***
Adjusted R^2	0.49	0.49	0.49	0.49	0.49	0.49	0.49
No. observations	35887	35887	35887	35887	35887	35887	35887

Table 10
Robustness Tests: Regressions for Above and Below Median Product Market Fluidity Subsamples

This table reports results of pooled OLS regressions on firm efficiency for 1997-2010. The sample includes firms for which Hoberg et al.'s (2014) product market competition variable, product market fluidity (PMF) is available. The product market fluidity variable is downloaded from http://alex2.umd.edu/industrydata/industryconcen. htm. Columns 1, 3, and 5 report results from OLS regressions on a subsample of firms with a PMF above the sample median (i.e., high level of strategic interaction). Columns 2, 4, and 6 report results from OLS regressions on a subsample of firms with PMF below the sample median (i.e., low level of strategic interaction). The data come from Compustat, Census of Manufactures, and the *Use* table of benchmark input-output accounts from Bureau of Economic Analysis. *Log(Assets)* is the natural logarithm of market value of assets, *PP&E/Assets* is the ratio of net property, plant, and equipment to book value of total assets, *Leverage* is ratio of total debt to market value of assets, *ROA* is operating income before depreciation divided by book value of total assets, and *Market-to-Book* is market value of assets divided by book value of assets. *PF1 Rivals* is an intensity score based on *Compustat HHI* (10 for the bottom decile through 1 for the top decile). *PF2 New Entrants* is an intensity score based on *ENTCOST* (a measure of entry costs; 10 for the bottom decile through 1 for the top decile). *PF3 Substitutes* is an intensity score based on *DIFF* (a product differentiation measure; 10 for the bottom decile through 1 for the top decile). *PF4 Customer Power* is an intensity score based on the concentration of customer industries (10 for the top decile through 1 for the bottom decile). *PF5 Supplier Power* is an intensity score based on the concentration of supplier industries (10 for the top decile through 1 for the bottom decile). Since the dependent variable (firm efficiency) ranges from zero to one, we also scale intensity scores by the maximum value for each year (so they also range from zero to one). Year dummies and Fama and French (1997) industry dummies are included in the regressions, but are not reported. Standard errors are clustered at the firm level and are robust to heteroskedasticity. * p<0.10, ** p<0.05, *** p<0.01.

	(1) Efficiency	(2) Efficiency	(3) Efficiency	(4) Efficiency	(5) Efficiency	(6) Efficiency
	Above Median PMF	Below Median PMF	Above Median PMF	Below Median PMF	Above Median PMF	Below Median PMF
Log(Assets)	0.008***	0.010***	0.009***	0.010***	0.009***	0.010***
PP&E/Assets	-0.056***	-0.095***	-0.060***	-0.098***	-0.062***	-0.096***
Leverage	0.024	0.000	0.026*	0.002	0.027*	0.001
ROA	0.098***	0.051***	0.098***	0.052***	0.097***	0.052***
Market-to-Book	0.010***	0.008***	0.010***	0.008***	0.010***	0.008***
PF1 Rivals	-0.001	-0.008				
PF2 New Entrants	-0.038**	0.030***				
PF3 Substitutes	-0.008	0.017**				
PF4 Customer Power	-0.098***	0.041***				
PF5 Supplier Power	0.006	-0.002				
Horizontal Comp			-0.051***	0.044***		
Vertical Comp			-0.142***	0.055***		
Porter's Five Forces					-0.156***	0.087***
Constant	0.506	0.834***	0.507	0.812***	0.518	0.814***
Adjusted R^2	0.41	0.45	0.41	0.45	0.41	0.45
No. observations	17993	17894	17993	17894	17993	17894

Appendix A – Frontier Efficiency Methodology

The concept of economic efficiency flows directly from the microeconomic theory of the firm. The efficiency of a firm is defined by comparing the observed value with the optimal value of its vector of inputs and outputs. Efficiency can be characterized by either output shortage for a given level of input or input excess for a given level of output. Both yield identical values. Conditioning on a specific output vector, a firm is considered fully efficient if its actual input usage equals optimal input usage and inefficient if its actual input usage exceeds optimal input usage. A production frontier indicates the minimum inputs required to produce any given level of output for a firm operating with full efficiency. Figure A.1 shows a production frontier, V, for a firm with one input and one output. Firm *i* is operating at point (x_i, y_i). This firm could operate more efficiently by moving to the frontier, i.e., by reducing its input usage. The firm's level of technical efficiency, TE(x,y), is given by the ratio Oa/Ob (Farrell (1957)).

To measure technical efficiency we estimate a "best-practice" frontier for each firm. Specifically, we use Data Envelopment Analysis (DEA), which uses a standard linear programming technique to pinpoint a peer group of efficient firms for each firm being evaluated. There are several different ways to present DEA technical efficiency problems, but the simplest representation for firm *i* is the following:

$$\text{TE}(x_i,y_i) = \min \theta_i$$

$$\text{subject to: } Y\lambda_i \geq y_i,\ X\lambda_i \leq \theta_i x_i \text{, and } \sum_{i=1}^{S} \lambda_i = 1. \qquad \text{(A.1)}$$

where firm subscript i=1,2,…,S. Y is an N x S output matrix and X is a M x S input matrix for all firms' in the sample; y_i is an N x 1 output vector and x_i is an M x 1 input vector for firm *i*; and λ_i is an S x 1 intensity vector for firm *i*. The constraint $\sum_{i=1}^{S} \lambda_i = 1$ imposes variable returns to scale

(VRS). Firms with elements of λ_i that are non-zero are the set of "best-practice" reference firms for the firm under analysis. Efficiency, θ_i, is between zero and one.

Although DEA was traditionally viewed as a strictly non-parametric methodology, research has shown that it can be interpreted as a maximum likelihood procedure (e.g., Banker, 1993). In addition, the DEA estimator is consistent and converges faster than other estimators (Grosskopf, 1996). As such, the asymptotic distribution of the DEA estimators is identical to the true distribution of the efficiency. DEA efficiency estimates, however, are biased upward in finite samples (e.g., Simar and Wilson, 1998). To correct the upward bias of our efficiency estimates, we implement the bootstrapping procedure of Simar and Wilson (2000) with 1000 bootstrap replications. To estimate and bootstrap efficiency we use FEAR, a package for frontier efficiency analysis in R (Wilson, 2007).

Below we provide a numerical example to illustrate what this measure represents and how it is computed. Suppose there are four firms and each firm uses two inputs, labor and capital, to generate sales:

Firm	Labor (X_1)	Capital (X_2)	Sales
1	1000	5000	20000
2	2000	2000	20000
3	4000	1000	20000
4	4000	3000	20000

Figure A.2 presents the four firms and the piece-wise linear best-practice frontier, i.e., the isoquant for a firm with one output and two inputs. The isoquant represents the various combinations of the two inputs required to produce a fixed amount of the single output using the best available technology. Firms operating on the isoquant are considered to be technically efficient. Firms 1, 2, and 3 are on the best-practice frontier and are thereby technically efficient. Firm 4 is not. It could reduce its input usage by adopting the best technology. Using DEA, we can show that Firm 4 is only 60 percent efficient relative to its peers, implying the firm could produce the same level of output with 60 percent of the inputs actually utilized.

For Firm 4, the DEA linear programming problem is:

$$\max_{\lambda i}(-\theta)$$

subject to:

$$20000\lambda_1 + 20000\,\lambda_2 + 20000\,\lambda_3 + 20000\,\lambda_4 \geq 20000$$

$$1000\,\lambda_1 + 2000\,\lambda_2 + 4000\,\lambda_3 + 4000\,\lambda_4 \leq 4000\theta$$

$$5000\,\lambda_1 + 2000\,\lambda_2 + 1000\,\lambda_3 + 3000\,\lambda_4 \leq 3000\theta$$

$$\lambda_1 + \lambda_2 + \lambda_3 + \lambda_4 = 1$$

$$\lambda_1 \geq 0,\ \lambda_2 \geq 0,\ \lambda_3 \geq 0,\ \lambda_4 \geq 0$$

The lambdas (λ) are the weights on each input or output of the firm. In this simplified example, the first constraint is equivalent to the fourth constraint, so the Lagrangian of the objective function and constraints is:

$$L = -\theta - \gamma_1 (\lambda_1 + 2\lambda_2 + 4\lambda_3 + 4\lambda_4 - 4\theta)$$

$$- \gamma_2 (5\lambda_1 + 2\lambda_2 + \lambda_3 + 3\lambda_4 - 3\theta)$$

$$- \gamma_3 (1 - \lambda_1 - \lambda_2 - \lambda_3 - \lambda_4)$$

$$+ \gamma_4\lambda_1 + \gamma_5\lambda_1 + \gamma_6\lambda_1 + \gamma 7\lambda_1$$

Taking the first-order conditions:

$$\frac{\partial L}{\partial \theta} = 0 => -1 + 4\gamma_1 + 3\gamma_2 = 0 \qquad (FOC\ 1)$$

$$\frac{\partial L}{\partial \lambda_1} = 0 => -\gamma_1 - 5\gamma_2 + \gamma_3 + \gamma_4 = 0 \qquad (FOC\ 2)$$

$$\frac{\partial L}{\partial \lambda_2} = 0 => -2\gamma_1 - 2\gamma_2 + \gamma_3 + \gamma_5 = 0 \qquad (FOC\ 3)$$

$$\frac{\partial L}{\partial \lambda_3} = 0 => -4\gamma_1 - \gamma_2 + \gamma_3 + \gamma_6 = 0 \qquad (FOC\ 4)$$

$$\frac{\partial L}{\partial \lambda_4} = 0 => -4\gamma_1 - 3\gamma_2 + \gamma_3 + \gamma_7 = 0 \qquad (FOC\ 5)$$

$$\gamma_1(\lambda_1 + 2\lambda_2 + 4\lambda_3 + 4\lambda_4 - 4\theta) = 0 \qquad (FOC\ 6)$$

$$\gamma_2(5\lambda_1 + 2\lambda_2 + \lambda_3 + 3\lambda_4 - 3\theta) = 0 \qquad (FOC\ 7)$$

$$\gamma_3(1 - \lambda_1 - \lambda_2 - \lambda_3 - \lambda_4) = 0 \qquad (FOC\ 8)$$

$$\gamma_4\lambda_1 = \gamma_5\lambda_2 = \gamma_6\lambda_3 = \gamma_7\lambda_4 = 0 \qquad (FOC\ 9-12)$$

To solve the system of equations, we iteratively examine different values for the γ 's. Take the case where $\gamma_5 = \gamma_6 = 0$. From FOC 3 and FOC 4, we find $\gamma_2 = 2\gamma_1$, which yields the following:

$$-1 + 4\gamma_1 + 6\gamma_1 = 0 \qquad (FOC\ 1)$$

Therefore, $\gamma_1 = \frac{1}{10}$ and $\gamma_2 = \frac{1}{5}$, which using FOC 3 implies $\gamma_3 = \frac{3}{5}$. Substituting these values into FOC 2 and FOC 5 yields $\gamma_4 = \frac{1}{2}$ and $\gamma_7 = \frac{2}{5}$. The feasible set of multipliers ($\gamma_1 - \gamma_7$) is $\left(\frac{1}{10}, \frac{1}{5}, \frac{3}{5}, \frac{1}{2}, 0, 0, \frac{2}{5}\right)$. Since $\gamma_4 \neq 0$and $\gamma_7 \neq 0$, then FOC 9-12 indicate that $\lambda_1 = \lambda_4 = 0$. Using these values, FOC 6-8 become:

$$2\lambda_2 + 4\lambda_3 = 4\theta$$

$$2\lambda_2 + \lambda_3 = 3\theta$$

$$\lambda_2 + \lambda_3 = 1$$

Solving these equations shows that $\theta = 0.6$, $\lambda_2 = 0.8$, and $\lambda_3 = 0.2$. Hence Firm 4 is only 60 percent efficient relative to its peers. Since λ_2 and λ_3 are non-zero they represent the set of “best-practice” reference firms for Firm 4. Firms 1, 2, and 3 can be shown to have 100% efficiency through similar procedures.

Figure A.1
Firm Efficiency – One Input and One Output

This figure shows a production frontier for a firm with one input and one output. A production frontier indicates the minimum inputs required to produce any given level of output for a firm operating with full efficiency. Firm *i* is operating at point (x_i, y_i). The firm's level of technical efficiency, TE(*x*,*y*), is given by the ratio Oa/Ob.

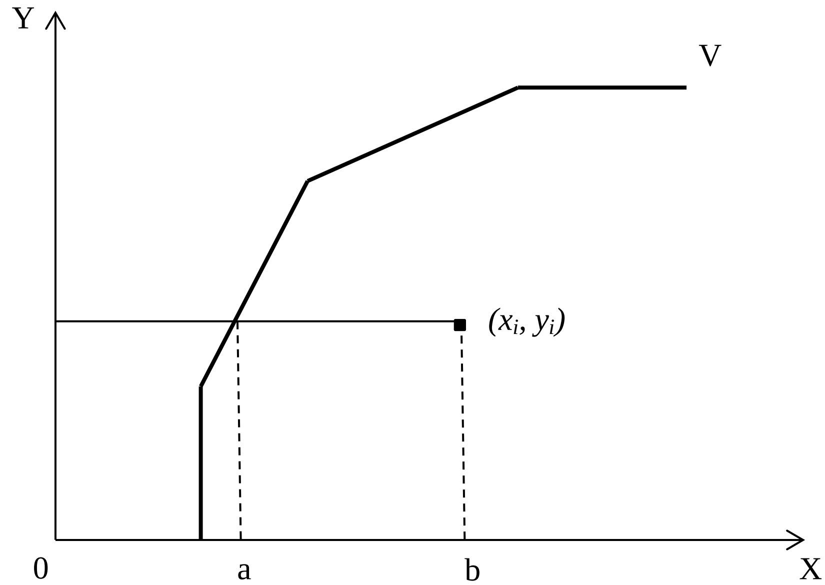

Figure A.2
Firm Efficiency – Two Inputs and One Output

This figure shows the piece-wise linear best-practice frontier for four firms, each of which uses two inputs, labor and capital to generate sales. The isoquant represents the various combinations of the two inputs required to produce a fixed amount of the single output using the best available technology. Firms operating on the isoquant are considered to be technically efficient.