Industry Classification and The Relationship between Profitability and Competition: A Study of The US Manufacturing Industry

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Abstract

This paper examines how the relationship between profitability and competition changes with narrowing industry classification—and what implications that carries for policy makers and future antitrust laws. The sample is comprised of panel data for 1178 US manufacturing firms between 2002 and 2012, covering approximately 26% of the total market capitalization and 19% of all public businesses in the US for 2012. Four measures of competition are used to cover and cross-validate the research question; the number of firms, market share, market concentration and the Herfindahl-Hirschman index. Results offer weak evidence that (i) profitability decreases with competition, and (ii) explanatory power between firm profitability and market competition increases with narrowing industry classification. Additionally, profitability is shown to increase with lagged profitability, firm growth and productivity, and decrease with leverage and financial stress.

Keywords: Profitability, Competition, Industry Classification, Manufacturing, Antitrust, Monopolistic Competition, Oligopoly, Herfindahl-Hirschman Index, Concentration Ratio, Market Share

JEL Classification: D41, D42, D43

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Contents

1 Introduction

The relationship between competition and profitability is one of the oldest and most foundational frameworks in modern economics. Its roots can be traced all the way back to the late 19th century, when Léon Walras established the first consensus on market dynamics under perfect competition. With the later arrival of oligopoly- and monopolistic competition theories during the 1930s, researchers were finally able to understand these dynamics under more realistic market conditions, i.e. in markets with fewer participants, information asymmetries, non-homogeneous products and substantial barriers to entry—collectively known as *characteristics of imperfect competition*. Although many additional sophisticated models and theories have since been developed, the theorized relationship between profitability and competition has almost uniformly remained negative.

According to Bradford et al. (2019), 127 countries had adopted some form of antitrust regulations by 2010, with 76 alone originating from the two decades before that. In contrast, such competition laws were largely nonexistent prior to the late 19th century, with Canada becoming the first adopter in 1889. This signifies just how seriously the issue of competition is handled by 21st century market regulators. According to Rogowsk and Shughart (1982), one can not overemphasize the importance of proper industry classification, which serves as a backbone for any of said antitrust regulations and merger policies. Rogowsk and Shughart also point out that economic theory offers no consistently reliable criteria for defining relevant markets. The question than becomes, just how important is it to define relevant markets and what are the consequences of not doing so—that is, does market definition actually affect the explanatory power between profitability and competition?

The purpose of this thesis is to answer this very question, focusing specifically on 1178 firms from the US manufacturing industry between 2002 and 2012. Using fixed-effects regression, the results offer weak evidence that the explanatory power between firm profitability and market competition increases with narrowing industry classification. While the effects are neither consistent nor homogeneous across different measures of competition, antitrust regulators should still prioritize the monitoring of narrowly defined markets over broader ones. The remainder of this paper will focus on how these findings were derived; namely by describing previous literature on the subject, the theoretical framework, data used in the estimation, model specification and different types of empirical econometric analyses.

1.1 Hypothesis

This thesis is centered around two main hypotheses, one to validate the relationship between profitability and competition against previous literature, and another one to answer the main theme of this paper—*how does narrowing industry classification affect the relationship between profitability and competition?* As such, the first hypothesis examines whether or not profitability is negatively influenced by competition. This formulation stems from the theory of monopolistic competition by Chamberlin (1962) and oligopoly by Sweezy (1939) (see Section 3), as well as empirical evidence by McDonald (1999), Feeny and Rogers (2000) and Tan and Floros (2014) (see Section 2.1). The second hypothesis asks whether or not the explanatory power between profitability and competition increases with narrowing industry classification. This carries the rational that broadly defined markets contain many businesses that do not compete with each other directly—e.g. producers of cat food and producers of guided missiles—while narrowly defined markets are more likely to contain businesses that do—e.g. producers in the semiconductor market.

2 Literature Review

The subject of profitability and competition is—perhaps unsurprisingly—one of the largest fields in modern day economic theory, with a substantial body of previous research, literature and documentation covering its many aspects and relationships. This study uses a select few high-quality research papers that are frequently referenced by other authors.

2.1 Profitability and Competition

In a research paper by Aiginger (1993), a study of 886 firms in 97 sectors, market concentration is shown to be either negatively correlated with profitability, or not statistically significant at all. The author argues that this likely occurs due to multicollinearity issues between market concentration and firm size, the latter of which is estimated to be negatively related to profitability. However, it is important to note that these findings strongly contradict empirical evidence by Yazdanfar (2013), in which profit margins increase with firm size. The negative effect of market concentration also contradicts the findings of McDonald (1999), who found that concentration positively influences a firm's profitability.

Feeny and Rogers (2000) use firm-level data of 722 large Australian firms to show that profitability increases when market share exceeds 30%. Their results suggest that Australian merger policy guidelines are well placed and in support of current empirical evidence[1]. The authors' also allude to a U-shaped relationship between market share and profitability, suggesting that the relationship between both factors is more complicated than previously theorized. Tan and Floros (2014) also confirm the negative relationship between profit margins and competition, this time in a study of 101 Chinese commercial banks between 2003 and 2009.

2.2 Determinants of Profitability

In an empirical study by McDonald (1999), lagged profitability is shown to be a statistically significant determinant of current profit margins, displaying a very strong positive relationship. These results are based on firm-level data from the Australian manufacturing industry between 1984 and 1993. Fourteen years later, Yazdanfar (2013) published very similar evidence, this time examining 12,530 Swedish firms between 2006 and 2007. In addition to the positive effects of lagged profitability, the author also finds that profit margins increase with firm size, firm growth and productivity, and decrease with firm age and industry affiliation. Out of all aforementioned factors, Yazdanfar shows that productivity is the most significant determinant of profitability.

In more recent years, Fareed et al. (2016) expanded Yazdanfar's (2013) framework to Pakistan's power and energy sector, focusing on 16 firms between 2001 and 2012. In addition to lagged profitability, firm size, firm growth, firm age and productivity, Fareed et al. also examine the relationships between profitability, financial leverage and Pakistan's recent electricity crisis. Their results are mostly in line with the previous findings of Yazdanfar and McDonald (1999); however, the relationship between profitability and productivity is estimated to be negative rather than positive. Moreover, profitability is shown to be positively influenced by the electricity crisis and negatively correlated with financial leverage. Similarly to Yazdanfar, Fareed et al. find that firm size and productivity are among the strongest determinants of profitability.

[1] Australian Competition and Consumer Commission (ACCC) guidelines state that market shares in excess of 40% should be investigated (Feeny and Rogers, 2000).

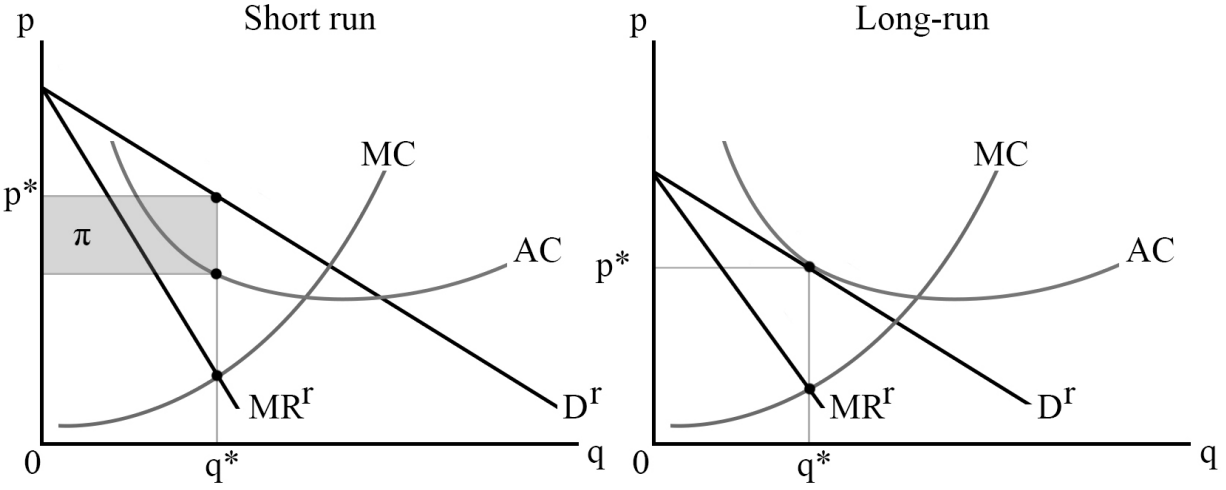
3 Theoretical Framework

3.1 Monopolistic Competition

In the year of 1933, Edward H. Chamberlin published his famous theory of monopolistic competition; a type of imperfect competition framework where markets are characterized by a large number of relatively small participants, no barriers to entry or exit, asymmetric information and differentiated products (Chamberlin, 1962). The existence of product differentiation and information asymmetries grant monopolistic competition producers some degree of market power, allowing them to earn super-normal profits[2] in the short run. However, in the long run these super-normal profits are eventually completely eroded by new market entrants, i.e. increased market competition (see Figure 1). The latter occurs because there are no barriers to entry that can prevent new firms from entering the market.

Figure 1: Profit Maximization under Monopolistic Competition—Short Run versus Long Run

p*—profit maximizing price, q*—profit maximizing quantity, MC—marginal cost curve, AC—average cost curve, D^r—residual demand curve, MR^r—residual marginal revenue curve, π—economic profit. Economic profit consists of total revenue minus explicit and implicit costs.



Source: Adapted from Chamberlin, E.H. (1962). The Theory of Monopolistic Competition. Eighth edition. Cambridge: Harvard University Press.

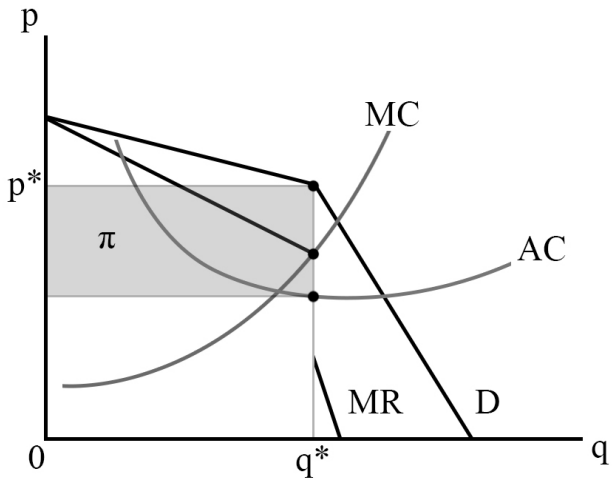
[2]Economic profit > 0

3.2 Oligopoly

Six years after Chamberlin's monopolistic competition theory, Paul Sweezy developed one of the more well-known oligopoly models—the kinked demand curve model (Sweezy, 1939). Oligopoly is a type of imperfect competition framework in which markets are characterized by a small number of large producers, identical or differentiated products and substantial barriers to entry (Sweezy, 1939). Similarly to monopolistic competition, oligopoly producers can earn short run super-normal profits due to their inherent market power. However, in contrast to monopolistic competition, oligopoly firms are able to sustain these super-normal profits even in the long run (see Figure 2). This is possible due to the existence of barriers to entry, preventing new competition from entering the markets and eroding profits.

Figure 2: Profit Maximization under Oligopoly—Sweezy's Kinked Demand Curve Model

p*—profit maximizing price, q*—profit maximizing quantity, MC—marginal cost curve, AC—average cost curve, D—demand curve, MR—marginal revenue curve, π—economic profit. Economic profit consists of total revenue minus explicit and implicit costs.



Source: Adapted from Sweezy, P. (1939). Demand Under Conditions of Oligopoly. *Journal of political Economy*, 47(4), pp. 568-573.

4 Data Description

The sample is comprised of annual firm-level- and industry-level data from the US manufacturing industry between 2002 and 2012. All firm-level data is gathered from Refinitiv Eikon, a powerful database with international coverage of real-time financial information, fundamentals and analyst recommendations. Key variables consist of company name, NAICS classification[3], company founding date, total debt, total equity, total assets, EBITDA, net sales[4] and total cost of revenue[5]. Financial stress is proxied using the St. Louis Fed Financial Stress Index (see Figure 5 in Section 6.1), which is comprised of different interest rate series, yield spreads and other indicators (St. Louis Fed, 2019). Industry-level data for the Herfindahl-Hirschman index[6], concentration ratios[7], value of shipments and number of firms are collected from the U.S. Census Bureau (2002–2012).

The sample contains two types of data issues: *missing values* and *outliers*. The first case of missing values consists of observations where the corresponding firms have not yet been founded, or failed, sometime within the studied time frame. The second case of missing values likely occurs due to reporting issues by Refinitiv Eikon or the companies themselves. Regarding the second data issue—*outliers*—these are created as a result of building the regression model variables. Observations containing such outliers are excluded in order to keep the remaining data description representative of the final sample[8].

As seen in Table I, there are enough firms in most NAICS sectors to conduct a satisfactory panel data analysis. Computer and electronic manufacturing (NAICS 334) and chemical manufacturing (NAICS 325) are the largest subsectors in terms of the number of constituents, mainly driven by their dominance in the fields of semiconductor manufacturing (NAICS 3344 and 334413) and pharmaceutical manufacturing (NAICS 3254 and 325412). However, the distributions in Table I are far from representative when sorting population data after the number of constituents, rather than after the value of shipments. This implies that Refinitiv Eikon's selection criterion is skewed towards larger businesses.

[3]North American Industry Classification System (U.S. Census Bureau, 2017)

[4]Sales receipts for products and services, net of cash discounts, trade discounts, excise tax, and sales returns and allowances (Thomson Reuters, 2012).

[5]Costs that are linked to goods and services produced, purchased and sold (Thomson Reuters, 2012).

[6]Based on the 50 largest companies in each industry.

[7]Based on the 4 largest companies in each industry.

[8]See Adjustments and Definitions for more details on the removal of outliers.

Table I: Distribution of Firms across the Most Prevalent US Manufacturing Industries in the Sample—Organized into 3, 4 and 6-digit NAICS Hierarchies

Displaying all companies in the sample that are contained within the top-10 largest 3-digit, 4-digit and 6-digit NAICS classification groups between 2002 and 2012. Size of each classification group is determined by the total number of constituent firms.

Code	NAICS Classification	Firms
	3-digit NAICS—Subsectors	
311	Food Manufacturing	50
325	Chemical Manufacturing	188
326	Plastics and Rubber Products Manufacturing	25
331	Primary Metal Manufacturing	40
332	Fabricated Metal Product Manufacturing	45
333	Machinery Manufacturing	114
334	Computer and Electronic Product Manufacturing	339
335	Electrical Equipment, Appliance, and Component Manufacturing	60
336	Transportation Equipment Manufacturing	88
339	Miscellaneous Manufacturing	81
Total		**1030**
	4-digit NAICS—Industry Groups	
3251	Basic Chemical Manufacturing	46
3254	Pharmaceutical and Medicine Manufacturing	88
3341	Computer and Peripheral Equipment Manufacturing	28
3342	Communications Equipment Manufacturing	61
3344	Semiconductor and Other Electronic Component Manufacturing	121
3345	Navigational, Measuring, Electromedical, and Control Instruments Manufacturing	114
3359	Other Electrical Equipment and Component Manufacturing	33
3363	Motor Vehicle Parts Manufacturing	33
3391	Medical Equipment and Supplies Manufacturing	54
3399	Other Miscellaneous Manufacturing	27
Total		**605**
	6-digit NAICS—Industries	
325193	Ethyl Alcohol Manufacturing	16
325412	Pharmaceutical Preparation Manufacturing	56
331111	Iron and Steel Mills and Ferroalloy Manufacturing	18
334210	Telephone Apparatus Manufacturing	23
334220	Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing	28
334413	Semiconductor and Related Device Manufacturing	74
334419	Other Electronic Component Manufacturing	18
334510	Electromedical and Electrotherapeutic Apparatus Manufacturing	50
334511	Search, Detection, Navigation, Guidance, Aeronautical, and Nautical System and Instrumen.	18
339112	Surgical and Medical Instrument Manufacturing	37
Total		**338**

Source: Refinitiv Eikon Database.

Overall, the sample is comprised of 1178 firms and 7587 observations, covering close to 26% of the total market capitalization- and 19% of all public businesses in the US for 2012[9]. There are two potential sources of selection bias in the collected data set. First, the previously discussed selection criterion by Refinitiv Eikon, which seems to skew the data towards substantially large businesses. Second, only listed firms are included in the sample, excluding a substantial piece of the total US manufacturing industry[10]. However, for the intents and purposes of this study, the sample contains enough raw data to be deemed representative and satisfactory.

5 Methodology

5.1 Adjustments and Definitions

The purpose of this section is to clarify the underlying data adjustments and definitions used in the estimation. One key aspect of this thesis is *competition*, but competition can be measured in several different ways and capture significantly different things. Four measures of competition are used to cover and cross-validate this aspect: the *number of firms*, *market share*, *market concentration* and the *Herfindahl-Hirschman Index*. All four metrics are specified at the 3-digit, 4-digit and 6-digit NAICS level for the years of 2002, 2007 and 2012. The missing information between 2003 to 2006 and 2008 to 2011 is filled using natural cubic spline interpolation. *Market share* is the only variable in the data set that consists of both firm-level and industry-level data; where each firm's net sales are divided by their corresponding industry totals[11].

The remaining variables are based on the frameworks of [A] Yazdanfar (2013) and [B] Rajan and Zingales (1995), combining the most compelling definitions from each. [B] *Profitability* ratio is defined as earnings before interest, taxes, depreciation and amortization (EBITDA) to total assets. [B] *Firm size* is proxied using the natural logarithm of net sales. [A] *Firm growth* rate is calculated as current year's net sales less last year's net sales, all divided by last year's net sales. [A] *Firm age* is the difference between 2012 and the firm's founding date. [B] *Financial leverage*, or simply *leverage*, is the ratio of total debt to total capital,

[9]The US market capitalization was $18.67 trillion in 2012 (The World Bank, 2019). There were a total of 4102 public firms in the US in 2012 (The Global Economy, 2019).

[10]There were a total of 267 thousand manufacturing firms the US in 2012 (U.S. Census Bureau, 2012).

[11]Measured at the 3-digit, 4-digit and 6-digit NAICS level.

where the latter is comprised of total assets- and equity. Last but not least, [A] *productivity* consists of net sales divided by the total cost of revenue.

Under certain circumstances, these adjustments and calculations create extremely unrealistic values, *outliers*, which make it very difficult to estimate valid results. As such, these outliers are removed by truncating all variables to three times their interquartile range above and below the first and third quartiles, respectively[12] (see Table A1 in Appendix A). Slightly more than half of the original sample (58%) is deleted after the removal of outliers, decreasing the total number of firms from 2835 to 1178.

5.2 Econometric Model

The next ordeal is to specify an appropriate regression model; one which fits the sample data and answers the research question—*how does narrowing industry classification affect the relationship between profitability and competition?* First, three similar but separate models are created, covering the 3-digit, 4-digit and 6-digit NAICS hierarchies. Second, all models are estimated four times, once for each measure of competition. Changes in explanatory power are captured by comparing said models to each other, in particular, by examining how the R^2 and the coefficients of competition change with narrowing industry classification[13]. In the case of R^2, the value will increase if narrowing industry classification explains a larger proportion of the variance. The same can be said for the coefficients of competition, but with regards to significance and theoretical fit rather than variance.

Examining Figure B1 through Figure B4 (see Appendix B) reveals that the relationship between profitability and firm size is rather nonlinear. This is likely a display of *economies of scale* and *diseconomies of scale*, where the former decreases long run costs due to large-scale advantages—thereby increasing profits—and the latter increases them again due to large-scale inefficiencies—thereby decreasing profits. To control for this nonlinear relationship, a squared version of *firm size* is included into all models.

The first model (see Equation 1) is specified to capture the true relationship between profitability and competition at the subsector-level (3-digit NAICS), while also controlling for its determinants and time trends. The latter is controlled for using a categorical

[12] Also known as *lower outer fence* and *upper outer fence* for detection of extreme outliers (NIST, 2019).
[13] Going from the 3-digit to 4-digit and 4-digit to 6-digit NAICS level.

variable[14], separating its influence from the other coefficients. The second and third models (see Equation 2 and Equation 3, respectively) are very similar to the first one, the only difference being that they capture said relationships at an industry group-level (4-digit NAICS) and industry-level (6-digit NAICS), respectively, rather than at a subsector-level. *Financial stress* is included to account for the shock of the financial crisis of 2007–2008.

$$\begin{aligned}\text{Profitability}_{it} = \alpha_{it} &+ \beta_1\text{Lagged Profitability}_{it} + \beta_2\text{Firm Age}_{it} + \beta_3\text{Firm Size}_{it} \\ &+ \beta_4\text{Firm Size}^2_{it} + \beta_5\text{Firm Growth}_{it} + \beta_6\text{Leverage}_{it} \\ &+ \beta_7\text{Productivity}_{it} + \beta_8\text{Financial Stress}_t \\ &+ \beta_9\text{Competition (3-digit)} + \beta_{10\to19}\text{Year} + \varepsilon_{it}\end{aligned} \tag{1}$$

$$\begin{aligned}\text{Profitability}_{it} = \alpha_{it} &+ \beta_1\text{Lagged Profitability}_{it} + \beta_2\text{Firm Age}_{it} + \beta_3\text{Firm Size}_{it} \\ &+ \beta_4\text{Firm Size}^2_{it} + \beta_5\text{Firm Growth}_{it} + \beta_6\text{Leverage}_{it} \\ &+ \beta_7\text{Productivity}_{it} + \beta_8\text{Financial Stress}_t \\ &+ \beta_9\text{Competition (4-digit)} + \beta_{10\to19}\text{Year} + \varepsilon_{it}\end{aligned} \tag{2}$$

$$\begin{aligned}\text{Profitability}_{it} = \alpha_{it} &+ \beta_1\text{Lagged Profitability}_{it} + \beta_2\text{Firm Age}_{it} + \beta_3\text{Firm Size}_{it} \\ &+ \beta_4\text{Firm Size}^2_{it} + \beta_5\text{Firm Growth}_{it} + \beta_6\text{Leverage}_{it} \\ &+ \beta_7\text{Productivity}_{it} + \beta_8\text{Financial Stress}_t \\ &+ \beta_9\text{Competition (6-digit)} + \beta_{10\to19}\text{Year} + \varepsilon_{it}\end{aligned} \tag{3}$$

where:

$$\begin{aligned}\text{Competition} &= (1) \quad \log(\text{Number of Firms})_t \\ &= (2) \quad \text{Herfindahl-Hirschman Index}_t \\ &= (3) \quad \text{Concentration Ratio}_t \\ &= (4) \quad \text{Market Share}_{it} \\ i &= \text{firm} \\ t &= \text{year}\end{aligned}$$

Next, all models have to be estimated using an appropriate estimation method. There

[14]The year of 2002 is omitted in order to avoid perfect multi-collinearity (dummy variable trap).

are three main alternatives: *pooled* regression, *fixed-effects* regression and *random-effects* regression. Seeing as the sample contains panel data[15], i.e. information with both within-group- and between-group variation, it is likely that a panel regression is required to estimate consistent and efficient results. First, the choice between pooled- and random effects regression is determined by the *Breusch and Pagan Lagrangian Multiplier Test*[16]. The test is significant, implying that there are significant differences between groups, i.e. firms, and that random-effects regression is a better choice than pooled regression. Second, the choice between random-effects- and fixed-effects regression is decided with the *Hausman Test*[17]. This test is also significant, meaning that there is correlation between the residuals and the regressors, and that fixed-effects regression is the final and most appropriate model. Last, *firm age* is excluded from all further analysis, seeing as it is a time-invariant factor that is already controlled for in fixed-effects regression model.

5.3 Inference Considerations

Once the results are estimated using the most appropriate model—in this case the *fixed-effects* regression—the next step is to evaluate the validity and strength of inference. This is done by diagnosing the residuals for normality and heteroskedasticity, where the former tests if the residuals are normally distributed, and the latter whether or not they have constant variance. As seen in Figure B5 (see Appendix B), all models produce reasonably normally distributed residuals, especially the ones with competition at the industry-level (6-digit NAICS). This indicates that the inference-aspect of the estimation is sound. Figure B6 (see Appendix B), on the other hand, reveals that there are issues with heteroskedasticity, something that can create unreliable standard errors and confidence intervals. Clustered-robust standard errors are implemented to remedy these issues, with clustering set around the 3-digit, 4-digit and 6-digit NAICS sectors[18]. It is also important to note that fixed-effects estimation with lagged dependent variables can cause *Nickell bias*[19].

Multicollinearity concerns are evaluated by inspecting the pairwise correlations between

[15]The panel data in the sample is unbalanced.
[16]H_0: There are no significant differences between groups.
[17]H_0: The residuals are uncorrelated with the regressors.
[18]Matching the NAICS-level of the estimated regression model.
[19]Where the fixed-effects estimator (β) is not consistently estimated, even as $N \to \infty$.

the regressors themselves and the four measures of competition. According to Dohoo et al. (1997), multicollinearity is certain to impact the estimation when pairwise correlations reach above 0.9—fortunately, this is not the case for any of the regressors (see Table A3 in Appendix A). Still, simplified versions of model one through three are created to test how the relationship between profitability and competition behaves in absence of firm-specific controls, i.e. without lagged profitability, firm size, firm growth, leverage and productivity.

6 Results and Analysis

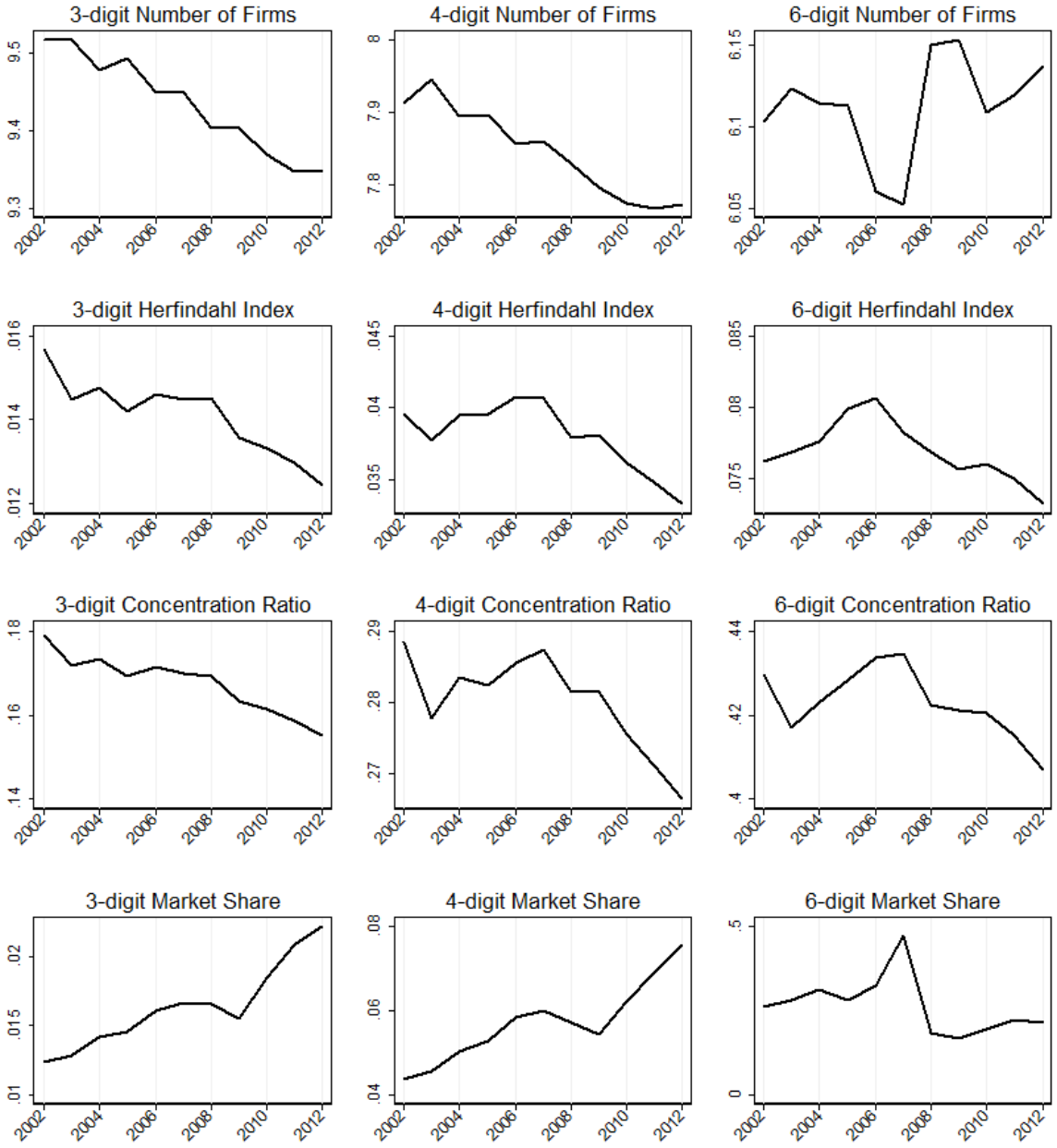
6.1 Graphical Evaluation

In order to fully grasp the relationships between competition, profitability and its determinants, it is beneficial to use more than just an econometric regression model. For instance, graphical analysis provides an otherwise missed opportunity to visually evaluate the different time-series patterns and discover if any of the proposed relationships occur instantly or with delays. Figure 3 through Figure 9 show the development of competition, profitability and its determinants in the US manufacturing industry between 2002 and 2012.

With regards to the four measures of competition (see Figure 3), the graphical analysis reveals some very interesting findings. First, it appears that the US manufacturing industry has seen a steady decline in the overall number of producers since 2002 (likely even earlier). Caliendo, Dvorkin and Parro (2015) attribute this to increased international trade with China, which according to the authors accounts for one-quarter of the decline between 2002 and 2007. Second, the Herfindahl-Hirschman index and concentration ratios are also shown to have been in steady decline since 2002, meaning that market power of the largest producers has weakened. One plausible explanation may be that large firms can more easily afford to move operations abroad, i.e. to China, thus leaving behind a less concentrated market once they exit the US. Third, when measured at the 6-digit NAICS level, both the number of firms and market share develop substantially different from their 3-digit and 4-digit counterparts. For the number of firms, the measure first decreases and then increases again, as opposed to steadily decreasing. For market share, the behaviour is approximately opposite to the one for the number of firms, across all NAICS levels.

Figure 3: The Number of Firms, Herfindahl-Hirschman Index, Concentration Ratios and Market Shares in the US Manufacturing Sector between 2002 and 2012—Presented across the 3, 4 and 6-digit NAICS Sectors

Calculated as the average annual number of firms, Herfindahl-Hirschman index, concentration ratios and market shares between 2002 and 2012. Market share is defined as each firm's net sales divided by their corresponding industry totals. The four measures are reported every five years, in 2002, 2007 and 2012. Missing information is filled using natural cubic spline interpolation.



The next step is to examine the relationships between profitability and competition (see Figure 4 and Figure 3, respectively) and see whether or not explanatory power changes with narrowing industry classification. Profitability and the first measure of competition—the number of firms—appear to be negatively correlated, especially so at the 6-digit NAICS level. This indicates that the relationship is in line with the hypotheses in Section 1.1. The relationship between profitability and the second measure of competition—market share—is approximately opposite to the one between profitability and the number of firms, although this time the increase in explanatory power at the 6-digit NAICS level is less apparent. Regarding the last two measures of competition—Herfindahl-Hirschman index and concentration ratio—the relationship with profitability appears to be weakly negative in both cases, with no apparent increase in explanatory power at the 6-digit industry classification. As such, there is partial evidence that explanatory power between profitability and competition increases with narrowing industry classification. However, the relationships are far from consistent enough to be considered as valid standalone results; therefore, further evaluation through a thorough multivariate regression analysis is required.

The last part of the graphical analysis concerns the control variables, i.e. the relationships between profitability and financial stress, firm growth, productivity, leverage and firm size. According to The Manufacturing Institute (2013), profitability in the US manufacturing sector is a highly cyclical phenomena, increasing in times of economic prosperity and decreasing in times of economic distress. This is seen by comparing profitability in Figure 4 to the financial stress index in Figure 5, where both factors correlate mostly negatively, especially during the financial crisis of 2007–2008. With regards to profitability and its determinants (see Figure 6 through Figure 9), it is seen that profitability increases with firm growth, productivity and firm size, and decreases with leverage. Moreover, changes in productivity seem to occur approximately one year before they occur in profitability. See Section 6.2 (Regression Analysis) for further elaboration and discussion of these results.

Figure 4: Profitability in the US Manufacturing Sector between 2002 and 2012

Calculated as the average annual profitability ratio between 2002 and 2012. Profitability ratio is defined as earnings before interest, taxes, depreciation and amortization (EBITDA) to total assets.

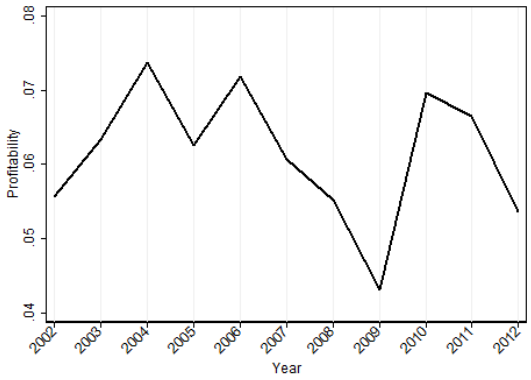


Figure 5: St. Louis Fed Financial Stress Index between 2002 and 2012

The underlying index is set to equal zero at its inception in late 1993. Positive values indicate above-average financial stress, while negative values indicate below-average financial stress (St. Louis Fed, 2019).

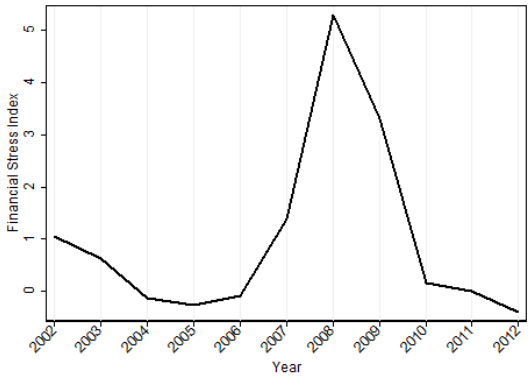


Figure 6: Firm Growth in the US Manufacturing Sector between 2002 and 2012

Calculated as the average annual firm growth between 2002 and 2012. Firm growth is current year's net sales less last year's net sales, all divided by last year's net sales.

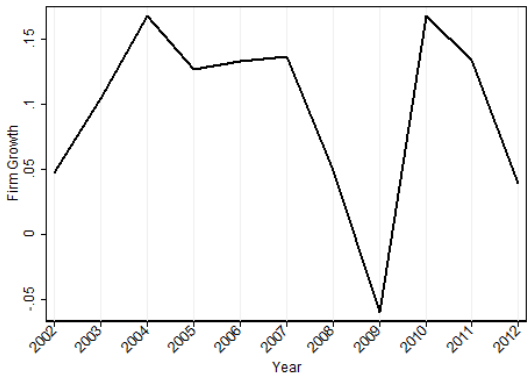


Figure 7: Productivity in the US Manufacturing Sector between 2002 and 2012

Calculated as the average annual productivity ratio between 2002 and 2012. Productivity ratio is defined as net sales divided by the total cost of revenue.

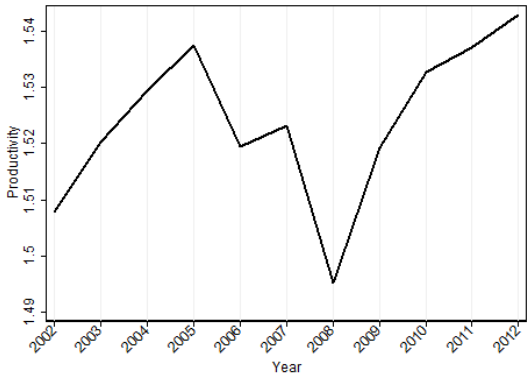


Figure 8: Leverage in the US Manufacturing Sector between 2002 and 2012

Calculated as the average annual leverage ratio between 2002 and 2012. Leverage ratio is defined as total debt to total capital.

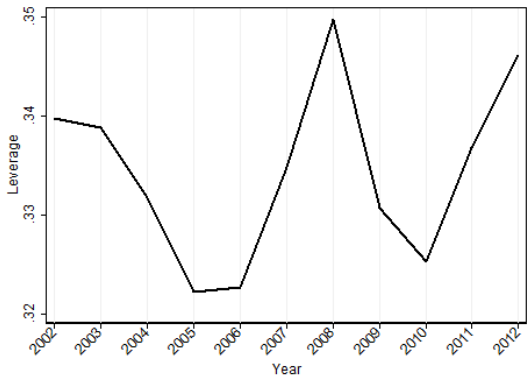
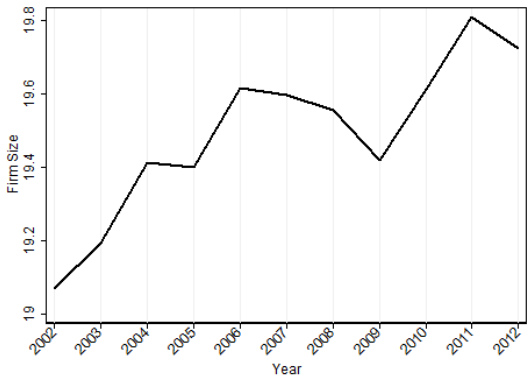


Figure 9: Firm Size in the US Manufacturing Sector between 2002 and 2012

Calculated as the average annual firm size between 2002 and 2012. Firm size is defined as the natural logarithm of net sales.



6.2 Regression Analysis

As seen in Table II, only one competition coefficient is statistically significant—the number of firms at the 6-digit NAICS level—which estimates that profit margins decrease as more firms enter the market. One standard deviation increase in the 6-digit number of firms decreases profitability by 2.99 percentage points, approximately half of the average profit margin in the sample[20]. It is also important to note that the other measures of competition—while not statistically significant—are more in line with theory at the 6-digit NAICS level than at the 3-digit and 4-digit levels. The exception to this being the Herfindahl-Hirschman index and concentration ratio, where the former is only in line with theory at the 4-digit level, while the latter is also in line with theory at the 4-digit level. Similarly, the R^2 also increases when going from the 3-digit to 6-digit NAICS classification, meaning that the models explain a larger percentage of the variance in profitability in more narrowly defined markets. The simplified regression models in Table A4 (see Appendix A) display very similar behaviour, with higher explanatory power and more theoretically valid competition coefficients at the 6-digit NAICS level as compared to the 3-digit and 4-digit levels. Another noteworthy difference between the models in Table II and Table A4 is that

[20]See Table A2 (Appendix A) for summary statistics on competition, profitability and its determinants.

the latter—while not more statistically significant—has slightly more theoretically valid coefficients for the Herfindahl-Hirschman index and concentration ratio.

Table II: The Relationship between Competition, Profitability and its Determinants for US Manufacturing Firms between 2002 and 2012: Presented across the 3-digit, 4-digit and 6-digit NAICS Sectors

Profitability is defined as EBITDA to total assets. Firm size is the natural logarithm of net sales. Firm growth is current year's net sales less last year's net sales, all divided by last year's net sales. Leverage is defined as total debt to total capital. Productivity consists of net sales divided by the total cost of revenue. Financial stress is proxied using the St. Louis Fed Financial Stress Index. Competition consists of four different measures: the number of firms, Herfindahl-Hirschman index, concentration ratios and market shares. Market share is each firm's net sales divided by their corresponding industry totals. Results are generated by the 3-digit, 4-digit and 6-digit NAICS models (see Equation 1, Equation 2 and Equation 3, respectively), and estimated using fixed-effects regression with clustered-robust standard errors.

NAICS	L.Profit	Size	Size^2	Growth	Leverage	Product.	Stress	Competi.	R^2	Obs
Number of Firms										
3-digit	0.2416***	0.0387	0.0000	0.0862***	-0.0592***	0.2204***	-0.0043***	0.0117	0.3793	5974
	(0.03)	(0.03)	(0.00)	(0.01)	(0.02)	(0.03)	(0.00)	(0.03)		
4-digit	0.2417***	0.0390	0.0000	0.0862***	-0.0593***	0.2204***	-0.0044***	0.0103	0.3749	5974
	(0.04)	(0.04)	(0.00)	(0.01)	(0.01)	(0.03)	(0.00)	(0.02)		
6-digit	0.2416***	0.0375	0.0002	0.0848***	-0.0732***	0.2111***	-0.0053***	-0.0199**	0.3910	5399
	(0.04)	(0.06)	(0.00)	(0.01)	(0.02)	(0.03)	(0.00)	(0.01)		
Herfindahl-Hirschman Index										
3-digit	0.2415***	0.0372	0.0001	0.0861***	-0.0595***	0.2204***	-0.0046***	-0.2749	0.3797	5974
	(0.03)	(0.03)	(0.00)	(0.01)	(0.02)	(0.03)	(0.00)	(0.31)		
4-digit	0.2417***	0.0386	0.0000	0.0862***	-0.0591***	0.2203***	-0.0045***	0.1299	0.3797	5974
	(0.04)	(0.04)	(0.00)	(0.01)	(0.01)	(0.03)	(0.00)	(0.10)		
6-digit	0.2428***	0.0382	0.0001	0.0852***	-0.0737***	0.2111***	-0.0051***	-0.0124	0.3923	5399
	(0.04)	(0.07)	(0.00)	(0.01)	(0.02)	(0.03)	(0.00)	(0.08)		
Concentration Ratio										
3-digit	0.2414***	0.0376	0.0001	0.0861***	-0.0595***	0.2204***	-0.0046***	-0.0385	0.3799	5974
	(0.03)	(0.03)	(0.00)	(0.01)	(0.02)	(0.03)	(0.00)	(0.04)		
4-digit	0.2416***	0.0397	0.0000	0.0862***	-0.0593***	0.2202***	-0.0044***	0.0639	0.3778	5974
	(0.04)	(0.04)	(0.00)	(0.01)	(0.01)	(0.03)	(0.00)	(0.05)		
6-digit	0.2422***	0.0395	0.0001	0.0850***	-0.0731***	0.2109***	-0.0050***	0.0586	0.3881	5399
	(0.04)	(0.06)	(0.00)	(0.01)	(0.02)	(0.03)	(0.00)	(0.05)		
Market Share										
3-digit	0.2415***	0.0365	0.0001	0.0862***	-0.0592***	0.2203***	-0.0045***	-0.0175	0.3802	5974
	(0.03)	(0.03)	(0.00)	(0.01)	(0.02)	(0.03)	(0.00)	(0.01)		
4-digit	0.2415***	0.0375	0.0001	0.0861***	-0.0592***	0.2203***	-0.0045***	-0.0023	0.3803	5974
	(0.04)	(0.04)	(0.00)	(0.01)	(0.01)	(0.03)	(0.00)	(0.01)		
6-digit	0.2429***	0.0393	0.0001	0.0852***	-0.0738***	0.2111***	-0.0051***	0.0011	0.3920	5398
	(0.04)	(0.07)	(0.00)	(0.01)	(0.02)	(0.03)	(0.00)	(0.00)		

*, **, and *** reflect significance at 10%, 5% and 1%, respectively.

As for the control variables, the relationships are mostly consistent and significant across all measures of competition and NAICS classification hierarchies. Profitability is estimated to increase with lagged profitability, firm growth and productivity, and decrease with leverage and financial stress; where lagged profitability and productivity produce the strongest relationships. With regards to firm size, the coefficients are positive but not significant, implying that there is no statistical evidence for the presence of economies- or diseconomies of scale—at least not in the US manufacturing industry between 2002 and 2012. Most of the aforementioned relationships are in agreement with the findings from the graphical analysis (see Section 6.1) as well as previous research by McDonald (1999), Yazdanfar (2013) and Fareed et al. (2016). The only exceptions are firm size and productivity, which contradict Fareed et al. who found that those factors are the most significant determinants of profitability and that productivity is correlated negatively rather than positively. Then again, Yazdanfar and Fareed et al. contradict each other in that same regard. Overall, the models appear to have sufficient control over the determinants and their behaviour.

In summary, taking into account the findings from both the graphical- and regression analysis, there is weak evidence that the relationship between firm profitability and market competition is negative. These partial findings are in line with the theoretical market dynamics of monopolistic competition by Edward H. Chamberlin, the kinked demand oligopoly model by Paul Sweezy, as well as the empirical evidence by McDonald (1999), Feeny and Rogers (2000) and Tan and Floros (2014). Additionally, there are no statistically significant relationships that are in line with Aiginger (1999), who found that profitability is negatively correlated to market concentration. As for the role of industry classification, there is once again weak evidence that the explanatory power between firm profitability and market competition increases with narrowing industry classification. Despite weak evidence, antitrust regulators should prioritize the monitoring of narrowly defined markets over broader ones.

7 Conclusion

This paper examines how the relationship between profitability and competition changes with narrowing industry classification—following the hierarchies specified in the North American Industry Classification System (NAICS). According to Bradford et al. (2019), 127 countries had adopted some form of antitrust regulations by 2010, with 76 alone

originating from the two decades before that. According to Rogowsk and Shughart (1982), one can not overemphasize the importance of proper industry classification, which serves as a backbone for any of said antitrust regulations and merger policies. Rogowsk and Shughart also point out that economic theory offers no consistently reliable criteria for defining relevant markets. The question than becomes, just how important is it to define relevant markets and what are the consequences of not doing so—that is, does market definition actually affect the explanatory power between profitability and competition?

The sample is comprised of panel data for 1178 US manufacturing firms between 2002 and 2012, covering approximately 26% of the total market capitalization- and 19% of all public businesses in the US for 2012. Four measures of competition are used to cover and cross-validate the research question; the number of firms, market share, market concentration and the Herfindahl-Hirschman index. Each of these competition measures is tested in three similar but separate models, covering the 3-digit, 4-digit and 6-digit NAICS hierarchies. Fixed-effects regression is chosen as the most appropriate estimation method, which together with clustered-robust standard errors produced statistically valid results.

In order to fully grasp the relationships between competition, profitability and its determinants, two types of empirical analyses are used—graphical analysis and econometric regression analysis. Results offer weak evidence that (i) profitability decreases with competition, and (ii) explanatory power between firm profitability and market competition increases with narrowing industry classification. Additionally, profitability is shown to increase with lagged profitability, firm growth and productivity, and decrease with leverage and financial stress; where lagged profitability and productivity produce the strongest relationships. While the influence of industry classification on the relationship between firm profitability and market competition is neither consistent nor homogeneous across all measures of competition, antitrust regulators and policy makers should still prioritize the monitoring of narrowly defined markets over broader ones.

I strongly invite future research and development of this topic, both because of its important role in the creation of healthy market competition, as well as for the purposes of expanding the current theoretical body of market dynamics. One area of improvement has to do with the collected sample; rather than limiting the study to the US manufacturing industry, one could expand it to other sectors and countries, or do a standalone study in

a different market and later compare the results. Another area of improvement has to do with the chosen time period, primarily considering the fact that it contains the financial crisis of 2007–2008. This poses problems when trying to impute competition measures between 2008 and 2011, where the values for 2008 are likely to be substantially biased. One way to avoid such bias is to choose a different time period that does not contain significant financial distress, or use population data and create competition measures that do not require imputation or external sources. Third area of improvement has to do with the classification system itself; if possible, one should evaluate an even more detailed hierarchy, for example the unofficial 8-digit SIC system. This will further increase the likelihood of observing firms that are directly competing with each other. Last but not least, one could use economic profit[21], rather than business profit (or accounting profit), when running the regression analysis, given that the former is more in line with the theoretical framework.

[21]Economic profit is similar to business profit (or accounting profit) but also accounts for the opportunity costs of inputs.

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A Tables

Table A1: Truncation of Outliers According to The Outer Fence Method

Profitability is EBITDA to total assets. Firm size is the logarithm of net sales. Firm growth is current year's net sales less last year's net sales, all divided by last year's net sales. Firm age is 2012 less the firm's founding date. Leverage is total debt to capital. Productivity is net sales to total cost of revenue. Profitability, firm growth, leverage and productivity are ratios, where 1 is 100%. Following NIST (2019), lower outer fence = 1st quartile − 3(interquartile range) and upper outer fence = 3rd quartile + 3(interquartile range). Lower limit for firm age and leverage is set to 0.

Variable	Interquartile Range	1st Quartile	3rd Quartile	Lower Outer Fence	Upper Outer Fence
Profitability	0.53	-0.40	0.13	-1.99	1.73
Firm Size	4.25	16.21	20.47	3.46	33.22
Firm Age	21.00	12.00	33.00	0.00	96.00
Firm Growth	0.31	-0.05	0.26	-0.97	1.17
Leverage	0.38	0.12	0.49	0.00	1.63
Productivity	0.52	1.24	1.76	-0.32	3.32

Table A2: Summary Statistics

Profitability is EBITDA to total assets. Firm size is the logarithm of net sales. Firm growth is current year's net sales less last year's net sales, all divided by last year's net sales. Firm age is the difference between 2012 and the firm's founding date. Leverage is total debt to capital. Productivity is net sales to total cost of revenue. Market share is each firm's net sales divided by their corresponding industry totals. All variables except firm size, firm age and number of firms are ratios, where 1 is 100%.

Variable	Observations	Mean	Standard Deviation	Min Value	Max Value
Profitability	7587	0.06	0.21	-1.95	0.77
Firm Size	7587	19.50	2.51	8.85	26.30
Firm Age	7587	28.09	21.98	0.00	94.00
Firm Growth	7587	0.09	0.26	-0.96	1.17
Leverage	7587	0.33	0.28	0.00	1.62
Productivity	7587	1.52	0.45	0.00	3.31
3-digit Number of Firms	7581	15948.92	11850.51	1004.00	58008.00
4-digit Number of Firms	7581	4181.43	4730.93	73.00	35738.00
6-digit Number of Firms	6930	746.95	1122.16	3.00	19806.00
3-digit Herfindahl Index	7583	0.01	0.01	0.00	0.07
4-digit Herfindahl Index	7583	0.04	0.04	0.00	0.29
6-digit Herfindahl Index	6932	0.08	0.06	0.00	0.47
3-digit Concentration Ratio	7583	0.17	0.08	0.04	0.46
4-digit Concentration Ratio	7583	0.28	0.14	0.04	0.90
6-digit Concentration Ratio	6932	0.42	0.18	0.00	1.00
3-digit Market Share	7583	0.02	0.14	0.00	5.08
4-digit Market Share	7583	0.06	0.39	0.00	12.51
6-digit Market Share	6931	0.27	1.66	0.00	79.18

Table A3: Pairwise Correlations Matrix for Multicollinearity Detection

Profitability is defined as EBITDA to total assets. Firm size is proxied using the natural logarithm of net sales. Firm growth is calculated as current year's net sales less last year's net sales, all divided by last year's net sales. Leverage is defined as total debt to total capital. Productivity consists of net sales divided by the total cost of revenue. Financial stress is proxied using the St. Louis Fed Financial Stress Index. Competition consists of four different measures: the number of firms, Herfindahl-Hirschman index, concentration ratios and market shares. Market share is each firm's net sales divided by their corresponding industry totals.

	L.Profit	**Size**	**Growth**	**Leverage**	**Product.**	**Stress**
L.Profit	1.00					
Size	0.46	1.00				
Growth	-0.01	0.07	1.00			
Leverage	-0.04	0.12	-0.05	1.00		
Product.	0.04	-0.05	0.10	-0.15	1.00	
Stress	0.00	-0.01	-0.15	0.01	-0.02	1.00
Number of Firms	-0.06	-0.15	-0.03	-0.11	0.15	0.01
Herfindahl Index	0.05	0.17	0.02	0.07	0.01	0.00
Concentration Ratio	0.06	0.21	0.02	0.07	-0.02	0.00
Market Share	0.08	0.21	0.02	0.03	0.00	-0.01

Table A4: The Relationship between Profitability and Competition in The US Manufacturing Industry between 2002 and 2012: Presented across the 3-digit, 4-digit and 6-digit NAICS Sectors

Profitability is defined as EBITDA to total assets. Financial stress is proxied using the St. Louis Fed Financial Stress Index. Competition consists of four different measures: the number of firms, Herfindahl-Hirschman index, concentration ratios and market shares. Market share is each firm's net sales divided by their corresponding industry totals. Results are generated by the 3-digit, 4-digit and 6-digit NAICS models (see Equation 1, Equation 2 and Equation 3, respectively) without firm-specific control variables[a], and estimated using fixed-effects regression with clustered-robust standard errors.

[a]Lagged Profitability, Firm Size, Firm Age, Firm Growth, Leverage and Productivity.

NAICS	Financial Stress	Competition	R^2	Obs
Number of Firms				
3-digit	-0.0018	-0.0322	0.0000	7583
	(0.00)	(0.03)		
4-digit	-0.0017	-0.0221	0.0010	7583
	(0.00)	(0.03)		
6-digit	-0.0007	-0.0293*	0.0046	6932
	(0.00)	(0.01)		
Herfindahl-Hirschman Index				
3-digit	-0.0014	0.0204	0.0015	7583
	(0.00)	(0.33)		
4-digit	-0.0014	0.0326	0.0018	7583
	(0.00)	(0.10)		
6-digit	-0.0005	0.0617	0.0032	6932
	(0.00)	(0.12)		
Concentration Ratio				
3-digit	-0.0015	-0.0244	0.0013	7583
	(0.00)	(0.07)		
4-digit	-0.0013	0.0523	0.0016	7583
	(0.00)	(0.05)		
6-digit	-0.0005	0.1281*	0.0044	6932
	(0.00)	(0.07)		
Market Share				
3-digit	-0.0014	0.0157	0.0027	7583
	(0.00)	(0.02)		
4-digit	-0.0015	0.0152	0.0049	7583
	(0.00)	(0.01)		
6-digit	-0.0005	0.0013*	0.0033	6931
	(0.00)	(0.00)		

B Figures

Figure B1: Linear and Nonlinear Relationships between Profitability and Firm Size

Contains a scatter plot between profitability and firm size (gray), linear prediction (dashed line) and quadratic prediction (solid line). Profitability is on the y-axis.

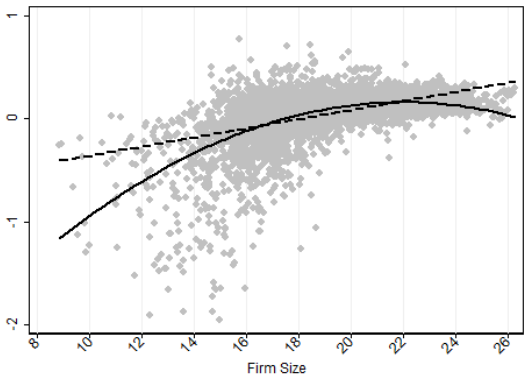

Figure B2: Linear and Nonlinear Relationships between Profitability and Firm Growth

Contains a scatter plot between profitability and firm growth (gray), linear prediction (dashed line) and quadratic prediction (solid line). Profitability is on the y-axis.

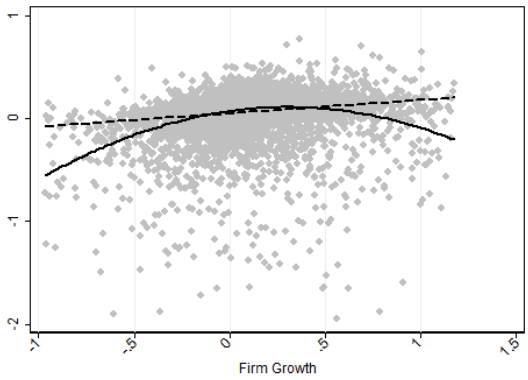

Figure B3: Linear and Nonlinear Relationships between Profitability and Productivity

Contains a scatter plot between profitability and productivity (gray), linear prediction (dashed line) and quadratic prediction (solid line). Profitability is on the y-axis.

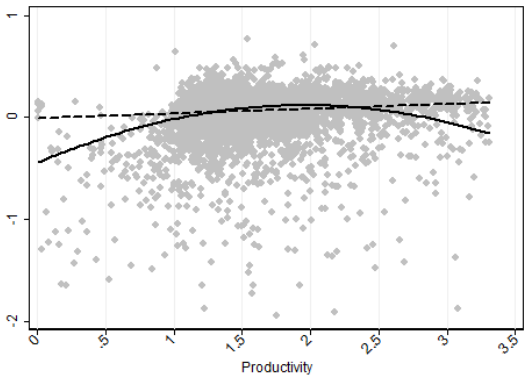

Figure B4: Linear and Nonlinear Relationships between Profitability and Leverage

Contains a scatter plot between profitability and leverage (gray), linear prediction (dashed line) and quadratic prediction (solid line). Profitability is on the y-axis.

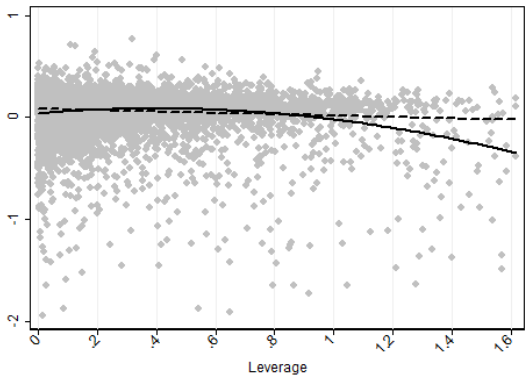

Figure B5: Normality Analysis across the 3, 4 and 6-digit NAICS Sectors and Competition Measures of the Number of Firms, Herfindahl-Hirschman Index, Concentration Ratios and Market Shares

Distribution of the standardized residuals (gray) against a normality plot (black). Standardized values have a mean on 0 and standard deviation of 1. The residuals are generated by the 3-digit, 4-digit and 6-digit NAICS models (see Equation 1, Equation 2 and Equation 3, respectively), which in turn are estimated once for each measure of competition—the number of firms, Herfindahl-Hirschman index, concentration ratios and market shares.

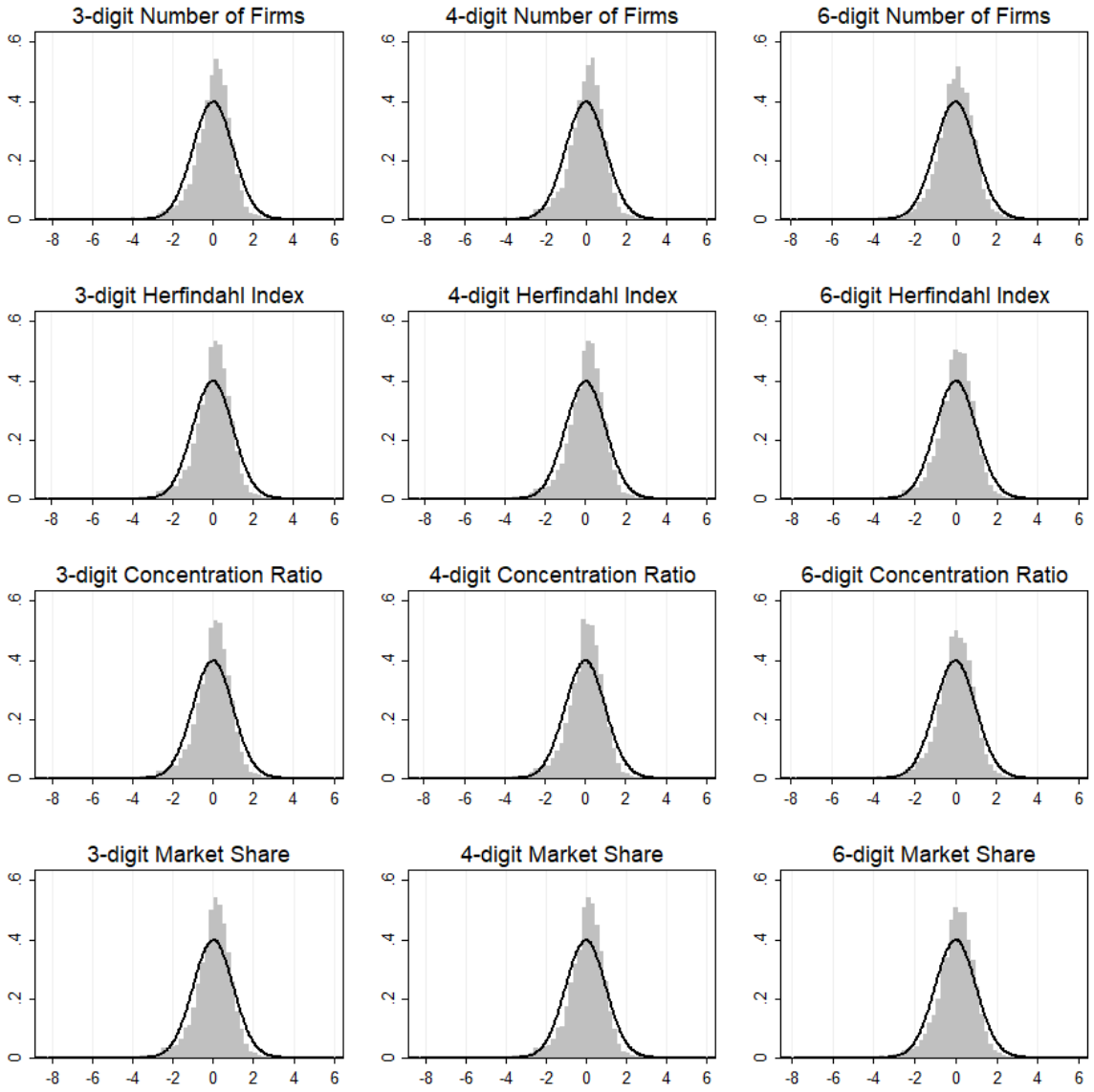

Figure B6: Heteroskedasticity Analysis across the 3, 4 and 6-digit NAICS Sectors and Competition Measures of the Number of Firms, Herfindahl-Hirschman Index, Concentration Ratios and Market Shares

Standardized residuals (y-axis) against the standardized predicted values (x-axis). Standardized values have a mean on 0 and standard deviation of 1. All values are generated by the 3-digit, 4-digit and 6-digit NAICS models (see Equation 1, Equation 2 and Equation 3, respectively), which in turn are estimated once for each measure of competition—the number of firms, Herfindahl-Hirschman index, concentration ratios and market shares.