Firm-Level Diversification and Response to Volatility in the US Manufacturing Sector, 1974-1998

Namsuk Kim *

Do firms adhere to a predetermined list of products, as in the widely used assumption in firm-behavior studies or do they keep a portfolio of products flexible over time? This paper uses the Longitudinal Research Database of the U.S. Bureau of Census from 1974 to 1998 to study the trend and cyclicality of firm/plant level diversification of the manufacturing sector in the United States. Empirical results find that firms use diversification as one of the adjustment margins, using within- and between-plant diversification whenever possible. Firm-level diversification decreases as the uncertainty decreases in the U.S. manufacturing sector.

Keywords: Diversification, Volatility, Business cycle, Firm-level adjustment

JEL Classification: E32, L25, L60

* Policy Specialist, Office of Development Studies, United Nations Development Programme, 336 East 45^{th} Street, UH-410, New York, NY 10017, USA, (Tel) +1-212-906-3681, (Fax) +1-212-906-3676, (E-mail) namsuk.kim@undp.org. This paper was written while the author was a research fellow at the Center for Economic Studies (CES), United States Bureau of Census. It has undergone a more limited review than official Census Bureau publications. All results were reviewed to ensure confidentiality. The author wishes to thank John Haltiwanger, Gordon Phillips, Lucia Foster, Ronald Jarmin, Keun Lee, as well as seminar participants at the CES, University of Maryland, Econometric Society 2005 World Congress, and Korea Research Association on Firm Studies for many helpful discussions. Likewise, the author would like to thank two anonymous referees for their suggestions. All remaining errors are the author's. The views expressed in this note are those of the author and do not necessarily reflect those of UNDP or US Bureau of Census.
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I. Introduction

The volatility of real GDP growth in the United States has fallen by half since the early 1980s relative to the prior postwar experience, as reported in Blanchard and Simon (2001) and McConnell and Perez-Quiros (2000). Inflation also stabilized after the mid-1980s. Some studies have argued that an improvement in U.S. monetary policy can explain both the lower output and inflation volatility (*e.g.*, Clarida, Gali, and Gertler 2000). Others have attributed the decreased GDP volatility to a reduction in the size of shocks hitting the U.S. economy (*e.g.*, Blanchard and Simon 2001). Some studies, such as Stock and Watson (2002) and Kahn *et al.* (2002), argue that both policy and shock size played a role, and that changes in inventory behavior stemming from improvements in information technology have also played a role in reducing real output volatility. Although the causes of volatility change have been studied, a consensus has yet to be reached.

Research on the effects of volatility change has accumulated as well. The response of firms to changing economic volatility or economic fluctuations has been studied along many types of adjustment margins that firms can use such as capital, labor, capacity and material, among others. However, product portfolio, one of the most important decisions that businessmen should make, also deserves more attention than the currently discussed topics in the literature.

Economists have followed the trend of multi-output production of manufacturing plants and firms; however, despite theoretical advances, the variation in diversification across industry and time still remains a mystery. Except for some anecdotal evidence, there are few publicly available statistics measuring short-term frequency of the extent of establishment, firm, or industry diversification. Gollop and Monahan (1991) have reported a diversification trend over an extensive time period, but only with infrequent time series which is not suitable for short term fluctuation analysis. Due to this lack of data, it has not been considered possible to study diversification along with business activity, although product diversification is one of the most important aspects of a firm's behavior.

In this paper, I study the effect of the volatility change related to firm-level product diversification. Section 2 reviews the relevant existing literature on diversification, and Section 3 discusses the stylized facts of diversification with the quality and limitations of the datasets. Section 4 contains empirical results of volatility change and diversification, and Section 5 contains the conclusion.

II. Literature Review

Diversification has been treated as an important firm characteristic in numerous studies. Many empirical papers on Total Factor Productivity (TFP), such as Giandrea (2002), and Gemba and Kodama (2001), included the firm's diversification level as a control variable. Research on large corporations, for instance, Kang and Lee (2008), considered diversification across affiliated companies as one of the key characteristics. Studies of the performance and financial constraints of the firm have included multi-product information, as seen in Bond and Cummins (2000), and Fazzari, Hubbard, and Petersen (1988). On the area of firm decision making, Whited (1992) and Winter (1999) have conjectured that diversified firms have different investment and entry/exit decisions.

There are numerous studies on diversification in the area of strategic behavior studies and corporate finances. Hermalin and Katz (2000) considered the agency theory for related diversification. Firms undertake a variety of actions to reduce risk through diversification. However, securities holders do not directly benefit from risk-reducing corporate diversification when they can replicate this diversification on their own. They argued that the value of diversification strategies in an agency relationship derives not from its effects on risk, but rather from its effects on the principal's information on the agent's actions.

Campa and Kedia (2002) have focused on the relationship between the decision of diversification and firm value. When they used panel data and instrumental variables to control for the exogenous characteristics that predict the decision to diversify, the evidence in favor of the assertion that diversification destroys value is weaker. When they jointly estimated the firm's decision to diversify and its firm value, diversification appeared to be a value-enhancing strategy. The diversification discount is more likely to be a premium in this case. They also found that firms refocusing their operations would have suffered a significant decrease in value if they had remained diversified, suggesting that the observed correlation between diversification and firm value is the outcome of actions by profit-maximizing firms reacting to shocks in their environments.

Villalonga (2004) has estimated the value effect of diversification by matching diversifying and single-segment firms on their propensity score — the predicted values from a probit model of the propensity to diversify. He also found that on average, diversification does not destroy value. These papers suggest that the decision of diversification is consistent with profit-maximization and that it is a reaction to exogenous environment.

Maksimovic and Phillips (2002) developed a model where the firm optimally chooses the number of segments in which it operates depending on its comparative advantage and industry demand shocks. Their model predicts firm-size distributions and investment as well as growth decisions of focused single-industry and multiple-segment firms. Plants of conglomerates are found less productive than plants of single-segment firms of a similar size, but this is consistent with the fact that conglomerates are value-maximizing, supporting the hypothesis that firms invest in industries in which they have a comparative advantage. Conglomerate firms also grow less in an industry if their other plants in other industries are more productive, and if their other industries have a larger positive demand shock.

Ng (2007), meanwhile, has proposed a conceptual model of unrelated diversification. Drawing on Penrose's (1959) resource-based approach, unrelated diversification is explained by an organization's three pillars: the strength of its dynamic capabilities, its absorptive capacity, and its weak ties. The role of the three pillars is to discover new resource applications or uses in conditions of market failure characterized by incomplete markets. The outcome would show that unrelated diversification can be beneficial.

A few papers have paid attention to the short-term dynamics of product diversification. Bernard, Redding, and Schott (2003) have explored a model of endogenous product selection by firms. They found the prevalence and importance of product-changing activity by U.S. manufacturers. In their model, firms make decisions on both industry entry and product choice, and the product choice is shaped by the interaction of heterogeneous firm characteristics and diverse product attributes. They focused on product switching and not diversification, using Census data available every five years, and showed that product switching can be another adjustment margin for firms.

This paper extends previous studies to build a more detailed profile of diversification as well as to examine its relationship with an exogenous environment. The segment, the traditional definition of industry in which firms diversify, is the three-digit Standard Industry Classification (SIC) in most of the papers mentioned above. The decision of diversification is often captured by a dummy variable which takes the value of one when firms diversify into multiple segments. Summary statistics in this paper will show diversification indexes measured by detailed product classification code. The annual time series of diversification index is then analyzed to determine the effect of the exogenous environment.

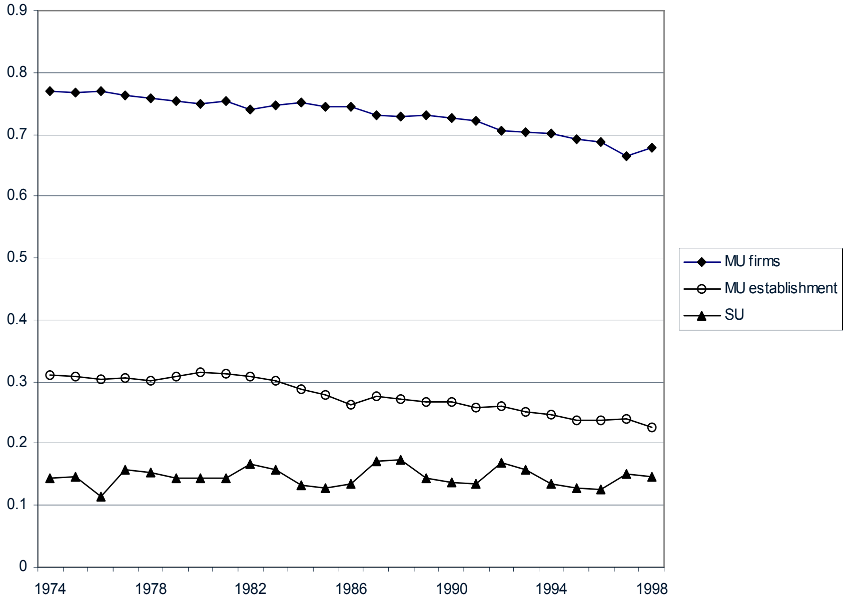
III. Measurement and Stylized Facts

The three datasets I used were the Census of Manufactures (CM), the Annual Survey of Manufactures (ASM), and the Longitudinal Business Database (LBD) from 1974 to 1998.[1] Of these, CM and ASM compose the Longitudinal Research Database (LRD), while LRD is a time series of economic variables collected from manufacturing establishments in CM and ASM programs. Of the three, LRD contains establishment-level identifying information, information on the factors of production and the products produced, as well as other basic economic information used to define the operations of a manufacturing plant. On the other hand, LBD provides longitudinally linked data for all employer establishments contained in the Census Bureau's business register, the Standard Statistical Establishment List (SSEL). Basic data items, such as payroll, employment, location, industrial activity and firm affiliation, are included in LBD, which is used to obtain data on firm age, total employment, and the number of plants of multi-unit firms.

Using LRD product files, I employed a Herfindahl-type index as a measure of establishment and firm-level diversification that has often been adopted in the literature, such as in Gollop and Monahan (1991). The diversification index satisfies the following properties: it varies directly with the number of different products produced; it varies inversely with the increasingly unequal distribution of products across product lines; and it is bounded between zero and unity. The diversification for firm j is defined as Equation (1).

$$D_j \equiv 1 - \sum s_i^2, \tag{1}$$

[1] CM is used for 1977, 1982, 1987, 1992, and 1997; ASM and LBD are made available on an annual basis.



Note: Firm/establishment diversification index is weighted by shipment.

FIGURE 1
DIVERSIFICATION INDEX, U.S. MANUFACTURING 1974-1998

where the share of product i (s_i) is the ratio of the shipment of product i to the total shipment of a firm. The product information is collected by SIC system. The details of the five-digit SIC code is available in ASMs, while the seven-digit SIC code is collected in CMs.[2] The product i is identified by the five-digit SIC code to obtain a consistent measurement from the entire sample. It is controversial how detailed product information should be used to define diversification. There are cases where some products with five-digit SICs are highly similar that the distinction may no longer be meaningful. In such cases, it is better to use less detailed product classification to construct the diversification index. Using a three- or four-digit SIC code however, does not change the main result of this paper qualitatively. From the sample, roughly 50% of the sample establishments produced a single product each year. About 25% produced two products, 10% produced three, 5% produced

[2] ASMs after 1998 were used in this paper in 1999 because of the consistency issue of industry (product) classification. See Appendix for a discussion.

TABLE 1

AVERAGE DIVERSIFICATION INDEX AND CORRELATION WITH GROWTH OF REAL SHIPMENT BY TWO-DIGIT SIC INDUSTRY

Industry	SU		MU establishments		MU Firms	
	Mean	Corr. coeff.	Mean	Corr. coeff.	Mean	Corr. coeff.
20 Food	0.19	-0.28	0.27	0.14	0.51	-0.30
22 Textile	0.13	0.26	0.20	0.36	0.57	-0.02
23 Apparel	0.17	0.53 *	0.22	0.64 *	0.61	-0.08
24 Lumber	0.18	-0.34	0.20	-0.57 *	0.63	-0.53 *
25 Furniture	0.16	-0.03	0.27	-0.14	0.56	-0.44
26 Paper	0.12	0.07	0.22	0.19	0.75	0.10
27 Printing	0.24	0.45 *	0.33	0.11	0.58	-0.67 *
28 Chemical	0.18	-0.42 *	0.37	-0.45 *	0.77	-0.71 *
29 Petroleum	0.27	0.36	0.59	0.65 *	0.71	0.00
30 Rubber	0.15	0.25	0.20	0.66 *	0.71	0.53 *
31 Leather	0.13	0.55 *	0.16	0.41 *	0.55	0.04
32 Stone	0.10	0.17	0.12	0.00	0.68	0.10
33 Metal	0.16	-0.11	0.30	0.52 *	0.70	-0.26
34 Fabricated Metal	0.14	0.03	0.17	0.39	0.72	0.34
35 Machinery	0.15	0.30	0.31	-0.18	0.73	0.45
36 Electronic	0.12	-0.25	0.21	-0.17	0.70	-0.28
37 Transportation	0.13	0.25	0.22	-0.44 *	0.75	-0.01
38 Instruments	0.11	0.09	0.23	-0.33	0.80	0.07
39 Miscellaneous	0.09	0.56 *	0.18	0.20	0.81	-0.30

Notes: 1) * denotes significance at the 95% confidence level.
2) Industry 20 includes industry 21 (Tobacco) due to a private information disclosure issue.

Source: Growth rate of real shipments are from *ASM: Reports* by Census Bureau (various issues).

four, and 5% produced five or more products.

Figure 1 displays the overall trend of diversification of Multi-unit (MU) firms, establishments of MU firms, and Single-unit (SU) firms (or establishments). The downward trend is clear for MU firms and MU establishments. As can be seen, SU firms do not have a clear trend but show noticeable fluctuation over time. These SU firms account for about 65% of the sample, but when shipment has been weighted, they explained less than 10% of the sales. Therefore, when diversification index is aggregated for the entire manufacturing sector, MU firms or MU establishments explain most of the trend and fluctuations over time.

The average diversification index shows large variations across industries, as shown in Table 1. For SU establishments, Food, Lumber, Printing, Chemical, and Petroleum are the industries with high diversification. For MU establishments, Printing, Chemical, Petroleum, Metal, and Machinery have high diversification. For MU firms, Paper, Chemical, Machinery, Transportation Equipment, and Instruments have high diversification.

Cyclicality also varies across industries. The sign of the correlation coefficient between sectoral diversification index and sectoral growth rate of real shipments is mixed across industries. For SUs, four of five significant correlations are positive, while for MU establishments, five out of eight significant correlations have positive signs. Only four industries for MU firms show statistically significant correlations. Overall, there is no strong evidence that there is an industry-specific cyclicality in diversification.

Even when two multi-unit firms produce identical products, they can be different in terms of how they allocate production. For example, suppose Firm I produces product X in plant A and product Y in plant B. Firm II produces both X and Y in plant A and only X in B. Firm I owns two specialized plants, while Firm II has one diversified plant and one specialized plant, although they may have the same firm-level diversification index. The diversification index can thus be decomposed to distinguish these two types of firms. Equation (2) groups the products into two categories: those produced in multiple plants or those produced in a single plant. The share of production diversification factor (r_{pd}) reflects how the firm diversifies.

$$d = 1 - (\underbrace{\sum_{i \in A} S_i^2}_{\text{Diversified Production}} + \underbrace{\sum_{i \in B} S_i^2}_{\text{Specialized Production}}) = (r_{pd} + r_{ps})d, \tag{2}$$

where

$$r_{pd} = \sum_{i \in A} S_i^2 / \sum_i S_i^2, \quad r_{ps} = 1 - r_{pd}$$

$i \in A$ product i produced in multiple plants,

$i \in B$ product i produced only in one plant.

Equation (3) further investigates the link between establishment and firm diversification. Given that a firm is defined as the sum of its establishments, a firm's diversification must be a function of diversifi-

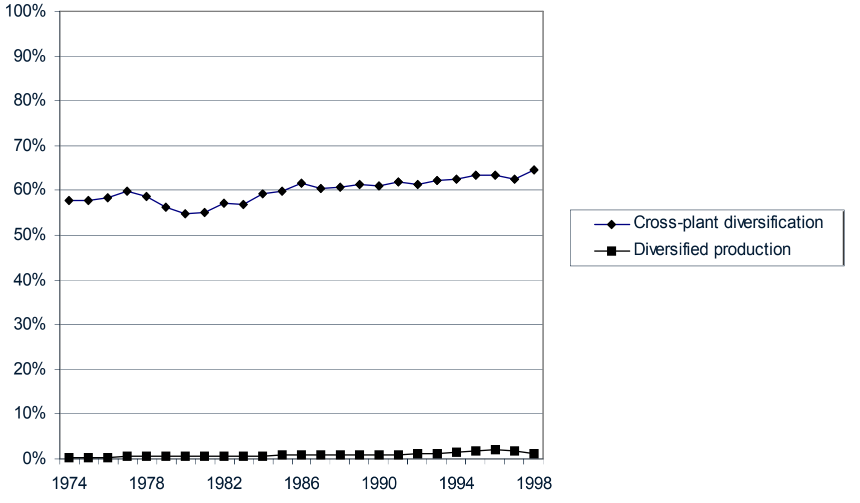


FIGURE 2
SHARE OF DIVERSIFIED PRODUCTION (r_{pd}) AND CROSS-PLANT DIVERSIFICATION (r_{wp}), U.S. MANUFACTURING 1974-1998

cation within and across its plants. Consider adding and subtracting a shipment-weighted average of diversification indexes for a firm's establishments to the right-hand side of an identity equating the firm's diversification index with itself. The within-plant factor reflects the contribution of within-establishment diversification to overall firm-level diversification. The cross-plant factor recognizes that differences in product mix across plants are captured in the firm measure but not in the individual plant measure. It quantifies the contribution of diversification among a firm's plants.

$$d^f = \underbrace{\sum_j a_j d_j^{est}}_{\text{Within-plant}} + \underbrace{(d^f - \sum_j a_j d_j^{est})}_{\text{Cross-plant}} = (r_{wp} + r_{cp}) d^f, \qquad (3)$$

where

a_j = shipment share of the j^{th} plant

d^f = firm level diversification, d^{est} = plant level diversification.

$r_{wp} = \sum_j a_j d_j^{est} \Big/ d^f, \quad r_{cp} = 1 - r_{wp}$

Figure 2 plots the share of diversified production (r_{pd}) and cross-plant diversification (r_{cp}) from 1974 to 1998. As can be seen, the diversified production factor increased a little in the late 1990s but remained below 2% during the entire sample period. This fact suggests that specialized production is much more common. On the other hand, the share of cross-plant diversification has been increasing. Two indicators in Figure 2 suggest that while firms specialize in each plant, they diversify more across plants.

IV. Volatility Change and Diversification

Many economic indicators showed less volatility in the mid-1980s and the change in volatility was not restricted to any one sector, level, or indicator. Stock and Watson (2002) have shown that the moderation in volatility is widespread and appears in both nominal and real series. The decline in volatility is most pronounced for residential investment, output of durable goods, and output of structures. The decline in volatility appears both in measures of real economic activity and in broad measures of wage and price inflation. The decline in aggregate volatility is pervasive.

Recent studies have shown that volatility has decreased not only at the aggregate level but also at the sectoral level. They find that the decrease is not confined to any one sector, but is common to many sectors. Kim *et al.* (2004) have shown that the volatility reduction in aggregate output is visible in more sectors of output than simply durable goods production. Specifically, there is evidence of volatility reduction in the production of structures and non-durable goods.

Comin and Mulani (2004) have investigated the evolution of volatility at the firm level. They found that while the growth rate of aggregate sales has become more stable over time at the firm level, the volatility of growth rate of sales at the same level has increased. They argued that idiosyncratic firm-level volatility diverges from the aggregate trend. However, they used the data only for exclusively public firms. It has not been confirmed whether idiosyncratic volatility has been increasing for all firms, including small non-public ones.

Among the potential motives for diversification listed by Jovanovic (1993), many studies have shown agreement to the assumption that firms are encouraged to diversify to avoid risks, that is, firms may diversify over products to smoothen their sales when firms' investments, especially for small firms, depend on cash flows because of liquidity constraints. If firms diversify over products to smoothen their profits, then they should respond to the volatility of profit shocks.

Intuitively however, firms' diversification decisions can be affected by sectoral and idiosyncratic volatility, but not by aggregate volatility. Firms can protect themselves against bad profit shocks by diversifying into different industries and products. However, firms cannot avoid aggregate shock because no matter how many products they produce, the aggregate shock will hit them equally. The aggregate shock in this analysis includes not only aggregate profit fluctuations of manufacturing sector but also any disturbance that is not captured by sectoral or idiosyncratic volatility in the economy. For example, fluctuations in the service sector, financial sectors, international trade environment, and globalization will change the aggregate volatility. The effect of aggregate volatility in this paper should thus be carefully interpreted.

Changes in volatility can affect diversification at different levels. More formally,

$$d_{it}=f(\sigma(A_{it})), \text{ where } i=1, 2, \ldots, N, t=1, 2, \ldots, T \tag{4}$$

$$A_{it} = \underbrace{A_t}_{\text{Aggregate factor}} + \underbrace{(A_{st} - A_t)}_{\text{Industrial factor}} + \underbrace{(A_{it} - A_{st})}_{\text{Idiosyncratic factor}}, \tag{5}$$

where $A_t = \frac{1}{N}\sum_i A_{it}, \quad A_{st} = \frac{1}{N_s}\sum_{i \in s} A_{it}$

$$\sigma(A_{it}) = \sqrt{\frac{\sum_{j=t-4}^{t+5}(A_{ij} - \overline{A}_{it})^2}{10}}, \quad \overline{A}_{it} = \frac{\sum_{j=t-4}^{t+5} A_{ij}}{10}. \tag{6}$$

Equation (4) implies the diversification for firm i (d_{it}) is a function of the volatility of profit rate (A_{it}). In Equation (5), the volatility of profit rate consists of three factors, namely, aggregate, industrial, and idiosyncratic factors. There are profit shocks at three levels (A_t, $A_{st}-A_t$, $A_{it}-A_{st}$), and the equation holds as an identity. The industrial and idiosyncratic components are defined as deviations from average industry or firm profit shocks. Equation (6) defines the volatility of time series for firm-level profits as ($\sigma(A_{it})$) by computing the series of standard deviations of a 10-year rolling window of A_{it}, following Comin and Mulani (2004).

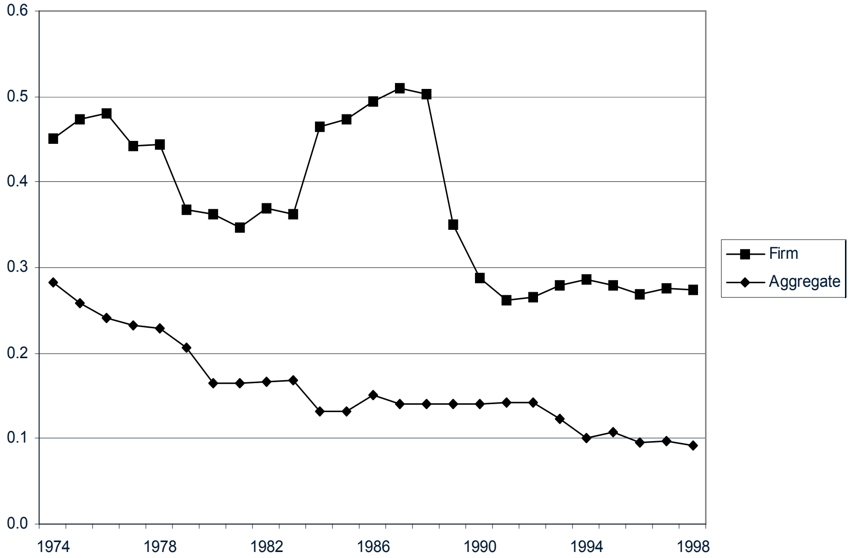


FIGURE 3
AGGREGATE AND FIRM-LEVEL PROFIT VOLATILITY,
U.S. MANUFACTURING 1974-1998

Profit shocks at the aggregate, industrial, and idiosyncratic levels are assumed to be orthogonal to one another by construction. Given that the shocks are orthogonal, the standard deviations of shocks over time (volatility) are orthogonal to one another as well. Therefore, orthogonality is preserved for the volatility of observed profit rates at all levels: the aggregate ($\sigma(A_t)$), industry ($\sigma(A_{st}-A_t)$), and the firm level ($\sigma(A_{it}-A_{st})$).

The data used in this paper reveal some interesting stylized facts about the volatility in the U.S. manufacturing sector. Figure 3 shows that the aggregate profit volatility ($\sigma(A_t)$) has constantly decreased over time; since I used a rolling standard deviation across 10 years as the measure of volatility, the volatility measure for the first four years is only forward looking, while volatility for the last five years is backward looking. Therefore, only the data between 1978 and 1993 are appropriate.

Table 2 shows the volatility of the average firm-level profit rate by industry. Almost all industries had lower profit volatility in 1993 than in 1978. The downward trend of volatility is observed in many industries, if not all. This is consistent with evidence found in the literature.

TABLE 2
PROFIT VOLATILITY BY TWO-DIGIT SIC INDUSTRY ($\sigma(A_{st}-A_t)$),
SELECTED YEARS

Industry	1978	1983	1988	1993
20 Food	0.19	0.13	0.13	0.11
22 Textile	0.14	0.10	0.12	0.15
23 Apparel	0.52	0.36	0.42	0.38
24 Lumber	1.07	0.06	0.11	0.12
25 Furniture	0.35	0.32	0.29	0.22
26 Paper	0.20	0.22	0.18	0.09
27 Printing	0.30	0.14	0.17	0.09
28 Chemical	0.21	0.28	0.31	0.13
29 Petroleum	0.82	0.72	0.33	0.41
30 Rubber	0.17	0.56	0.65	0.24
31 Leather	1.33	1.31	1.52	1.28
32 Stone	0.10	0.13	0.16	0.20
33 Metal	1.22	0.30	0.39	0.37
34 Fabricated Metal	0.07	0.18	0.20	0.04
35 Machinery	0.58	1.20	1.25	0.52
36 Electronic	0.94	0.73	0.31	0.54
37 Transportation	1.11	0.81	0.55	0.47
38 Instruments	0.44	0.28	0.52	0.47
39 Miscellaneous	1.21	1.08	0.36	0.21

Note: Industry 20 includes industry 21 (Tobacco) due to a private information disclosure issue.

There is some heterogeneity at the firm level, overall; however, the average idiosyncratic volatility decreased in 1990s compared to earlier years. The mean of firm-level profit volatility increased in the early 1980s but fell in the late 1980s as shown in Figure 3. The downward trend of idiosyncratic volatility is different from the evidence in the literature. This trend is commonly observed both for small and big firms.

Given these stylized facts of volatility, the firm-level diversification index is regressed on the volatility of aggregate, industrial, and firm-level profit rate.

$$d_{it} = \beta_0 + \beta_1 AGGVOL_t + \beta_2 INDVOL_{st} + \beta_3 IDIVOL_{it} + \beta_4 X_{it} + \varepsilon_{it}, \qquad (7)$$

where d_{it} is the firm-level diversification measure for firm i at time t; the subscript s represents the two-digit SIC industry for firm i; AGGVOL

TABLE 3
LEFT-CENSORED TOBIT ESTIMATION OF FIRM-LEVEL DIVERSIFICATION INDEX, U.S. MANUFACTURING 1978-1993

	I	II	III	IV
Intercept	-0.26**	-0.63**	-0.74**	-0.78**
	(.007)	(.006)	(.006)	(.007)
AGGVOL	-0.07	0.04**	1.36**	1.40**
	(.040)	(.030)	(.030)	(.030)
INDVOL	0.04**	0.02**	0.02**	0.02**
	(.003)	(.002)	(.002)	(.002)
IDIOVOL	0.07**	0.01**	0.01**	0.01**
	(.002)	(.002)	(.002)	(.002)
Aggprof	0.18**	-0.03**	-0.06**	-0.07**
	(.006)	(.005)	(.005)	(.005)
Indrpof	0.02**	-0.02**	-0.01**	-0.01**
	(.002)	(.001)	(.001)	(.001)
Idioprof	0.05**	-0.01**	0.00**	0.00*
	(.001)	(.001)	(.001)	(.001)
Size		0.13**	0.11**	0.11**
		(.001)	(.001)	(.001)
Age			0.01	0.01**
			(.000)	(.000)
Foe				0.16**
				(.007)

Number of Observations = 359,177
Non-censored Values = 156,234
Fixed Effects = YEAR, REGION
Name of Distribution = Normal

Note: * denotes significance at the 95% level, ** significance at the 99% level.

is the volatility of the average of firm-level profit rates ($\sigma(A_t)$); INDVOL is the volatility of the industry level average of the deviation from aggregate profit rates ($\sigma(A_{st}-A_t)$); and IDIVOL is the volatility of the deviation of firm-level profit rates from the industry average ($\sigma(A_{it}-A_{st})$). Firm-level characteristics (X) include the aggregate profit rate (AGG-PROF), the industrial profit rate (INDPROF) of the industry where the firm belongs, the idiosyncratic profit rate (IDIOPROF) of the firm, the firm size (SIZE), the firm age (AGE), and the share of organizational workers to the total employment (FOE).

Table 3 shows the results of firm-level regressions using the left-censored Tobit estimation method. By construction, single-product producers have a diversification index equal to zero. The left-censored Tobit model is appropriate because we have a mass point at zero for the dependent variable. Time trend (YEAR) and location (REGION) are controlled as fixed effects. The sample period is 1978-1993; the periods 1974-1977 and 1994-1998 have been excluded because the calculation of volatility in each year requires a complete 10-year rolling window.

The coefficient estimates for volatility (AGGVOL, INDVOL, and IDIOVOL) are positive and statistically significant for most cases. Coefficients for AGGVOL are different by the specification, but coefficients for INDVOL and IDIOVOL are relatively stable and robust. The result shows that diversification responds to aggregate volatility, industry volatility, and idiosyncratic volatility of firm performance. When other idiosyncratic firm-level characteristics (SIZE, AGE, and FOE) are included in the estimation, they change the magnitude of IDIOVOL and INDVOL coefficients, but do not reverse the signs.

The coefficient estimate for SIZE and AGE are positive, meaning that older firms with larger capacity typically diversify more. This fact suggests that bigger firms are associated with higher diversification (even after controlling for volatility hedging activities). This can be interpreted as an evidence of resource-based strategy of firm diversification that explains diversification as the longer-term capability to innovate.

The share of organizational workers to the total employment (FOE) is to capture the firm's organizational structure. The positive coefficient estimate means that firms with more organizational workers, such as managers, information technology clerks and human resource managers, tend to diversify more. The result suggests that firms can diversify more when production, management, and information handling is done through division of labor. It might have implications on the principal and agent problems within the firm, but it should be carefully studied with additional firm ownership information, which is not included in this paper.

In summary, regression results suggest that firm diversification responds positively to the volatility of aggregate, industrial, and idiosyncratic profit shocks. As the aggregate, sectoral, and firm-level volatility decreased in the U.S. manufacturing sector, firms have had less incentive to diversify against profit shocks. The results are fairly robust.

V. Conclusion

This paper discovers the trend of diversification in the entire U.S. manufacturing sector within a period of 30 years. My findings are summarized below:

(1) Aggregate diversification declined both at the establishment and firm levels since the early 1980s. The downward trend is common in many industries.
(2) Whether the diversification is pro-cyclical or counter-cyclical is not clear at the aggregate or industry levels.
(3) At the micro level, firms change diversification by utilizing all its components of within- and between-establishment and diversified- and specialized-production.

The trend of volatility is verified through the micro level data and new empirical relationship between diversification and volatility is found. Using firm-level profit rates, I found that: (1) the aggregate volatility declined; (2) the volatility decreased since the 1980s for most industries; and (3) the mean of firm-level idiosyncratic volatilities decreased in the late 1980s. The left-censored Tobit regression shows that the firm-level diversification is positively affected by the aggregate, industrial, and idiosyncratic profit volatility. Therefore, the decrease in volatility, that is, the reduced risks in U.S. manufacturing sector, contributes to the decrease of diversification.

Nevertheless, the results should be carefully interpreted. The relationship between the firm-level diversification and volatility is found in the data, but it does not provide conclusive evidence of why firms seek to diversify in the longer term. Is it because they could use the capacity for innovation (as explained in the resource-based theory), or because the structure of firm ownership affects the firm's decision (as explained in the agency theory)? Are the stylized facts of short-term and long-term trend unique to the United States, or are they similar in other countries? These questions remain for future empirical research.

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Appendix: Data and Variable Construction

Primary Data source: LRD and LBD

LRD: LRD provides a company-level database containing detailed statistics on research and development activities; and supports research on the issues of productivity, profitability, and the use of research and development. The database contains detailed company-level research and development information compiled from the annual Industrial Research and Development survey for survey years 1972 through 2001. Over the 30-year period, the total sample for the survey size has varied considerably. Since 1992, the total sample size has been fairly stable at approximately 25,000 companies. The sample design strategy has evolved over the years. The company has been defined as both the sample unit and the data collection unit since inception. Prior to 1992, a given sample was used for a number of years before being replaced. The probability of selection was a direct function of total company employment; companies with more than 500 employees were included with certainty.

LBD: LBD is a research dataset constructed at the Census Bureau's Center for Economic Studies. It is an establishment-based file created by linking the annual snapshot files from Census Bureau's Business Register over time. It contains high quality longitudinal establishment linkages. Firm-level linkages are currently under development at CES. Currently, LBD contains the universe of all U.S. business establishments with paid employees from 1976 to present; it also covers almost 24 million unique establishments from 1975 to present.

Supplementary Data source: NBER R&D and Productivity file from NBER, as well as statistics from *ASM: Annual Survey of Manufactures* published by the Census Bureau.

Diversification Index: I measured five-digit product diversification using LRD as described in the text. Five-digit product shares were calculated using TVPS/TVS where TVS (Total Value of shipments) represented the sum of TVPS (Total Value of Product Shipment) at the establishment level. For a firm-level index, the product shares were calculated using FTVPS/FTVS, where FTVPS and FTVS represented the sum of TVPS of a product produced in every plant of the firm and the sum of TVS across plants, respectively. Some product data were imputed and eliminated from the sample.

The ASM sample base used was the establishment rather than the firm; some establishments of a multi-unit firm were not selected in an ASM sample as this can distort the firm-level diversification measure of multi-unit firms. In most cases however, all the establishments of a multi-unit firm were included in an ASM sample. All the plants of a company, the so-called Certainty Companies, were included in ASM for certain, but many of the non-certainty multi-unit firms also have all of their plants in ASM. Matching ASM and LBD enabled us to find the establishments of a multi-unit firm which were not selected for the ASM sample. See LRD documentation for details.

Industry Classification: LRD classifies establishments by industry using the Standard Industrial Classification System (SIC). The structure of SIC makes it possible to tabulate, analyze, and publish establishment data on a two-, three-, or four-digit industry code basis, according to the level of industrial detail considered most appropriate. In addition to industry, the Census Bureau also collects and publishes information on product classes and individual products produced by manufacturing establishments. Product classes (five-digit codes) and products (seven-digit codes) of manufacturing industries are assigned codes based on the industry from which they originate. Beginning in 1997, the U.S., Canada, and Mexico began publishing and collecting statistics under the new North American Industrial Classification Systems (NAICS). Meanwhile, NAICS is based on a consistent, economic concept wherein establishments that use the same or similar processes to produce goods or services are grouped together. The SIC, developed in the 1930s and revised periodically over the past 50 years, is not based on a consistent economic concept. It is noteworthy that a major change in SIC occurred in 1987. Some industries are demand-based while others are production-based. From 1998, the product class in ASM is coded by NAICS.

Establishment and Firm Identifier: Permanent Plant Number (PPN) assigned to each establishment by the Census Bureau is used as the establishment identifier. For the single-unit firms/establishments, PPN begins with zero. For multi-units, the first six digits of the ten-digit PPN identify the firm.

Profit rate: Profit rate is measured by the nominal sales (TVS) minus the variable costs, divided by the capital stock. The variable costs are composed of total wage cost (SW) and total material costs (CM). Profit is deflated by GDP deflator. The book value of capital stock (MA and BA) is collected in ASM and CM and is deflated by the two-digit industry level deflator. The Bureau of Economic Analysis publishes two-digit industry capital stock both in nominal and real values. I use the ratio of the nominal capital stock to real capital stock as the two-digit industry level capital deflator. The base year for the deflator is 1996. The growth rate of real shipment (RTVS) is the symmetric growth measure: Growth of RTVS at time $t = (\mathrm{RTVS}_t - \mathrm{RTVS}_{t-1})/[(\mathrm{RTVS}_t + \mathrm{RTVS}_{t-1})/2]$.

Region: The Census Bureau divides the survey coverage area into nine regions in the sample: New England, Middle Atlantic, East North Central, West North Central, South Atlantic, East South Central, West South Central, Mountain, and Pacific.

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