

# **Transition of Firm Dynamics**

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**May, 2013**

**(very preliminary draft, do not quote)**

## **ABSTRACT**

This study employs a highly detailed panel dataset of product classifications to document the dynamics of firm entry and exit, and particularly the frequency with which firms both enter and exit different product markets within the same year, which we call “product turnover”. The longitudinal data from 1989 to 2004 allow us to investigate the path dependence of firm dynamics in product markets. The empirical findings identify systematic patterns that other researchers should note when choosing different product category systems, time windows, and samples to study diversification and related behaviors.

Keywords: Product Diversification, Product Turnover, Firm Dynamics, Panel Data.

## **1. INTRODUCTION**

The importance of firm dynamics, entry and exit, as a determinant of firm performance has been discussed theoretically and investigated empirically. Firm creation (entry) and destruction (exit) signal firm’s efficiency and inefficiency in the product life-cycle studies focusing on single-product firms (Jovanovic, 1982; Klepper, 1996). However, multi-product firms not only are non-trivial among the existing firms, but also contribute to the majority of gross production in the economy (Dunne, Roberts, and Samuelson, 1988). In a multi-product firm, product portfolio is considered as a whole, and the entry/exit decision is made with the evaluation of the overall portfolio performance. Literature of strategic management finds that divestment can be a strategic action to improve firm’s product portfolio performance, but not a failure activity (Berry, 2010). Bernard, Redding, and Schott (2010) also find a significant effect of net changes to the

product portfolio on firm performance. Despite of the recognition of the important role of net changes of diversification, little is known about the transition patterns of product turnover, gross product adding and gross dropping. We address this omission by providing summary of the patterns of firm's product turnover in 17 U.S. high-technology industries over the period 1989-2004.

The objective of this paper is to investigate the dynamics of the phenomena, including firm entry, exit, and the transition of multi-product firms' product turnover activities. Bernard, Redding, and Schott (2010), referred to BRS, find that an average of 54% of surviving firms alter their mix of products between Censuses. This study also finds that around 20% of the sample firms in high-tech industries adjust their product portfolio annually. BRS observes the significant effects of firm dynamics on firm's performance, and suggests the interdependence among products within a firm's product portfolio. However, the direction of the dynamics flow, changes of product portfolio mix and the shift of resources, is not studied in BRS. Diversification literature is known to be rich in theory, but is lack of data to test the developed theories. Datasets containing gross entry and exit for a large number of industries have only recently become available in several countries (Karlsson & Nystrom, 2003; Baldwin and Gorecki, 1987; Strotmann, 2007; Mata & Portugal, 1994; Sembenelli & Vannoni, 2000). These data are noted to be either limited by the duration gaps of observations, scope of covering industries, or by the level of generalization of the product classification, such as the Standard Industrial Classification (SIC) System. Research has emphasized on the correlation between firm performance and diversification, and the findings are controversial. Not only the causality is not concluded due to the deficiency of data periods (Bernard, Redding, & Schott, 2010), diversification as a corporate strategy is but also found to harm firm's performance (Schoar, 2002), when diversification is

measured without considering the dynamics of firm entry and exit. Theoretical development on diversification has been addressed with transaction cost economics (TCE) (Williamson, 1985), the resource-based View (Wernerfelt, 1984), and the real options theory (Kogut, 1991). TCE prescribes selecting a governance mode by comparing transaction costs among make or buy. Efficiency then follows the governance decision and results in a positive correlation between performance and the scope of diversification. Real options also suggest that firms' NPV increases with options. However, this is not in line with the controversial negative correlation between diversification and firm performance found in empirical studies. While theoretical discussions on diversification discount (Rajan, Servaes, & Zingales, 2000; Mansi & Reeb, 2002) and diversification relatedness (Markides & Williamson, 1994; Miller, 2006; Robins & Wiersema, 1995; Rumelt, 1974) are developed to explain the controversial findings, it is lack of discussion whether the controversial results are due to the limitation of the nature of available datasets. Diversification consists of scope expansion and divestment. Firms diversify in response to the developed excess capacity (Penrose, 1959), and firms divest for better profitability (Berry, 2010). A piece missing in the discussion is the product turnover activity. Firms frequently diversify and divest simultaneously (Bernard, Redding, & Schott, 2010). Resources flow with firms' scope expansion and contraction (Dunne, Roberts, & Samuelson, 1989). Thus, product turnover is likely to layout the transition of resource relocation. In this study, we use broad samples of firms from across the high technology industries to understand the phenomena of firm dynamics in the high technology industry.

Firm entry and exit are components of both industry dynamics and firm dynamics. Industry dynamics literature focuses on the product market, and seeks to explain firm entry, exit, and turnover of incumbents (Gort & Klepper, 1982; Jovanovic, 1982; Klepper, 1996; Figueiredo

& Silverman, 2007). Economists interpret market entry as a result of a firm's success, while exiting a market is a signal of failure, in the context of single-product firms. Different from the industry dynamics perspective, this study focuses on firms instead of focusing on product markets. Market entry and exit represent product adding and dropping. Thus, firm dynamics is the activities resulted from product portfolio selection. When researchers explain the factors that impacts firm dynamics (Figueiredo and Silverman, 2007; Moreno-Badia, Miranda, and Van Beveren, 2008; Wu, 2012), there is a lack of consideration of the transition of firm dynamics as a factor that drafts a layout of the resource reallocation within organization, thus might impact the firms' performance.

Using firm-level data from the CorpTech Directory for 17 high technology industries from 1989 to 2004, this study investigates how firms' previous product turnover decision leads to firms' current entry and exit activities. This data set is still limited in its scope of covering industries, high technology industries, but it provides a moderate product classification and collects data annually. Since the product classification in CorpTech is more detailed than the SIC System used in the Census and other business databases, the data in this study provides a better examination of the product turnover behavior based on an appropriately defined product market segment. Moreover, the annual data allows a robust check of the existing empirical studies that are restricted by the nature of the using data, such as the Census data with 5-year gaps. The panel data of the CorpTech demonstrate that product turnover is a frequent occurrence in high-tech industries, and the length of data allows us to observe product turnover with different time window. Four major findings are reported in this study. First, systematic differences are observed among different time windows and industries. Thus we suggest that sample selection matters the empirical results in studying firm dynamics. In our findings, time has a moderating effect on the

overall economy, industry level, and the firm level. Time indeed allows firms to increase their resource redeployability. Second, experiences can moderate the resource redeployability of firm-specific resources. Third, the empirical result is consistent with the theory suggested by Penrose (1959) that diversification contributes to a firm's growth. Expansion of a product portfolio signifies the growth of firm size and performance. Moreover, growing firms are more likely to continue on further growth. When being conditional on the events of product portfolio changes, firms act distinctly given the action in the previous period. Firms have a higher propensity to expand when we examine the firm dynamics with 1-year time window. Fourth, the patterns of the survival rates suggest that product turnover contributes to firm performances, and time moderates the effect of resource relocation.

The remainder of this paper is organized as follows. Section 2 provides an overview of the data set and summarizes the industry and firm attributes. Section 3 reports the transition of firms' product turnover. Firm performances are examined corresponding to distinct firm dynamics activities in section 4. Section 5 concludes.

## **2. SUMMARY OF DATA**

The data source is the CorpTech Directory, covering 90,891 business units and 17 high technology industries in the United States between 1989 and 2004 annually. The business units are operated by 67,017 private and public firms across 2,600 product markets within seventeen high-tech industries<sup>1</sup>. In the data set, each business unit is identified with a unique record id across all data years. Business-unit level data are aggregated into corporate level with the parent-

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<sup>1</sup> In the present study, we define the most detailed product category classified by CorpTech as a product market. The 2,600 product markets can be aggregated into 17 industries. The 17 industries in CorpTech are Factory Automation, Biotechnology, Chemicals, Computer Hardware, Defense, Energy, Environmental, Manufacturing Equipment, Advanced Materials, Medical Equipment, Pharmaceuticals, Photonics, Computer Software, Subassemblies and Components, Test and Measurement, Telecommunications and Internet, and Transportation.

subsidiary relation table in CorpTech. CorpTech is essentially a directory of high-tech industry manufacturers (Lavin, 1992). In addition to name, address, and other contact information, it also includes information on employment, firm-level sales, year of establishment, and a relatively fine-grained classification<sup>2</sup> system developed by CorpTech. Researches related to firm entry/exit have relied on directory with detailed product classification<sup>3</sup> heavily (see Gort and Klepper, 1982; Klepper and Graddy, 1990). CorpTech covers 2,600 products within 581 4-digit Standard Industrial Classification Codes. The data set also has an average of 19.33 newly added categories and 7.27 discontinued categories annually. Among the 2,600 categories across from 1989 to 2004, more than half (51.19%) of the product markets have increasing number of business units. It implies that about a half of product markets in high technology industries grow during 1989-2004. Since CorpTech provides fairly detailed level of product classification and it provides richer information than the SIC, the data allows researchers to better observe firm dynamics. In order to better understand the transition of firm dynamics, we have to focus on surviving firms. Thus we select firms that exclude observations of new entries and exits in CorpTech when we report the statistics of product turnover.

Net adding (NA), net dropping (ND), and product turnover (PT) are defined to categorize activities of firm dynamics within a given time frame. If a firm is neither net adding nor net dropping, it is categorized as non-change of level of diversification (NC). A firm is defined as a net adding firm if the number of products in its product portfolio increases; a firm is defined as a net dropping firm if the number of products in its product portfolio decreases. In such, firms are

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<sup>2</sup> CorpTech classifies products and industries at three different levels. For example, ENR-SV-U (Electric utility/energy providing services) is at the most detailed product classification. Thus we define this level as the product level. Then the ENR-SV is considered as the sub-industry level, while ENR (Energy) is used to classify the industry.

<sup>3</sup> The detailed product classification is classified with the product categories in The Thomas Register of American Manufacturers.

categorized into six categories: (1) ND, (2) NDPT, (3) NA, (4) NAPT, (5) NC, and (6) NCPT. Firm activities with 1-year, 2-year, and 4-year window are reported to show the robustness, and further test whether time increases redeployability. Table 1 tabulates the patterns of the ratio in each of the six firm dynamics categories. Table 1(a) reports the results when product turnover is observed with 1-year time window, and Table 1(b) is with 2-year time window. As it shows in the table, the percentage of firms which turnover products is higher with a greater time window. The result holds with the comparison between 1-year and 4-year time window. It is in line with the economic intuition that resources become mobile in the long run.

Summary statistics are shown by firm dynamics behavior. It attributes to examine whether diversification, divestiture, or both differ firm performance. Table 2 summarizes the key statistics by firm dynamics activities. Product Count is the number of categories that a firm manufactures in the CorpTech. Sales and Sales Per Product are used to examine firm performance. Firm age represents one of the key firm attributes, and the percentage of multi-division firm is also reported in the bottom row in Table 2. The statistics reported in column (1) & (2), (3) & (4), and (5) & (6) are paired to test their distinction. In each dyadic comparison among paired columns, there exists significant difference in Product Count, Sales, and Firm Age. The T-test statistics are significant at 2.80 % level. The significant difference is not captured in sales per product. Thus the statistical result only implies that firm size and firm dynamics behavior is highly related. Regarding to how firm performance is affected by the types of firm dynamics, it requires a better examination. Overall, the result suggests that the types of diversification do relate to firm attributes. Thus, research on changes in the level of firm diversification over time should take into account whether the firm is only entering new markets,

only exiting markets, or doing both, since there exist systematic differences in the firm attributes between firms with product turnover and firms without product turnover.

### **3. TRANSITION OF FIRM DYNAMICS**

A firm is a product turnover firm if it adds and drops products simultaneously. The t-year product turnover rate is estimated by dividing the number of turnover categories with the number of diversifying categories within t-year time window, where t equals 1, 2, and 4. The systematic differences in product turnover by industry are shown in Figure 1. The figure shows the 1-year, 2-year, and 4-year product turnover rate by 17 high technology industries in the CorpTech. 4-year turnover rate is greater than 1-year turnover rate across industries. It consists with the economic theory that fixed cost turns to be variable in the long run. The difference is exaggerated in Manufacturing industry, but shows no clear distinction in Subassemblies & Components industry. As it shows, firm dynamics is distinct across industries, thus it implies the industry-specific difficulties to relocate resources. In addition, time serves as a moderating effect to reduce the deterrence of turnover.

Product turnover rate is not only affected by industry-specific factors, firm-specific resources and capabilities also influence firms' ability to turnover products. A firm is considered to own firm-specific resources and capabilities if the firm ever hired a CEO from within. Figure 2 shows the 1-year, 2-year, and 4-year product turnover rate by Firm Age and Specificity in the CorpTech in 2(a), 2(b), and 2(c), respectively. As it is shown in the graph, elder firms might have more managerial experiences, but it does not guarantee a higher flexibility in product turnover. The most interesting finding in Figure 2 is that the firm specificity of resources and capabilities



deters product turnover when firms are still young, but the effects are moderated as firm ages. This finding is robust with 1-year, 2-year, and 4-year product turnover rate.

Firm size is considered highly correlated with diversification. Since product turnover is part of diversification activity, Figure 3 graphs the 1-year, 2-year, and 4-year product turnover rate by Firm Sizes. Firms in CorpTech are grouped by the range of their sales. Three groups are (1) sales less than 5 million, (2) sales between 5 to 10 million, and (3) sales greater than 10 million. For small size firms, the time effect does not affect the product turnover rate. As the size grows, the time effect takes greater and greater effect to moderate the product turnover rate.

The transition of firm dynamics layouts the flow of resource relocation. Table 3 reports the transition probability matrix of firm dynamics. It shows that 83.71 % of firms show no changes from year to year. The likelihood of being in a category in a given year is conditional on the category the previous year. For example, from the fourth column, 8.58% of firms that were simultaneously net adding and turnover products (NAPT) in the previous year were simultaneously net adding and turnover products (NAPT) again in the focal year; whereas only 1.20% of firms that did not change their product portfolio (NC) the previous year were simultaneously adding and turnover products (NAPT). To focus on the change activities, the conditional transition probabilities are computed. Conditional on the events of product portfolio changes, the highest conditional transition probabilities are graphed in Figure 4. Figure 4(a) and 4(b) graph the dynamics with 1-year window, while 4(c) and 4(d) shows the transition with 4-year window. Firms' propensity to act in a certain way is distinct corresponding to the action in the previous period. Firms have a higher propensity to expand when we examine the firm dynamics with 1-year time window. When we investigate the phenomena with a 4-year time

window, growing firms and firms with past product turnover are more likely to keep the momentum on further growth.

#### **4. PRODUCT TURNOVER AND PERFORMANCE**

The relation between firm performance and diversification has drawn quite an amount of discussion in literature. Section 2 uses the firm-level sales to represent firm performance, and it shows a significant difference among the six types of firm dynamics activities. However, no significance is captured in sales per product, thus it raises a concern of robustness of the statistical result. In this section, 3-year survival rate and 5-year survival rate are used to represent firm performance instead. Survival is known to be a necessary condition for production efficiency. Thus abler performed firms are expected to survive better in the market. In order to compare the trends of 3-year and 5-year survival rates, the firm dynamics activities of observations are limited to the duration from 1989 to 1999. Figure 5 graphs the 3-year and 5-year survival rates by the six types of firm dynamics activities. Figure 5(a), 5(b), and 5(c) show the patterns with 1-year, 2-year, and 4-year time window, respectively. The gap between 3-year and 5-year survival rates remains nearly a constant by firm dynamics activities given the same time window. However, the patterns of the survival rates differ in different time windows. With 1-year time window, firms that downsize their product portfolio not necessarily perform worse than average; with 4-year time window, downsizing indeed implies a higher propensity of failure. This hinders that research should take the duration of time window into consideration when interpreting the relation between firm dynamics and performance.

Moreover, Figure 5 shows an interesting phenomenon that firms do no changes to their product portfolio have the lowest survival rate than any other types of firms, even worse than the

downsizing firms. This implication indicates that a change is better than a rest when managing product portfolio.

## **5. CONCLUSION**

The present study uses a longitudinal database with precise product category classification to show the phenomenon that multiproduct firms alter their product portfolio frequently. The findings show the importance to consider the duration of time, industry-specific factors, and product turnover when researchers study product diversification at the firm level. This study contributes to the lack of discussion in the diversification literature regarding product turnover activities, and the moderating effects that are resulted from the gaps of time window. It is noted that the nature of data might affect the results of empirical studies of product diversification, and researchers are suggested to take the moderating effects into consideration while interpreting empirical results of firm dynamics.

Four major findings identify systematic patterns of firm dynamics in time, industry level, firm level as well as firm-specific resources. When firm-specific resources and industry specificity are known to limit resource redeployability, time and experiences are found to moderate the limitation. Moreover, product turnover is shown to be positively related to firm performances. Firms can improve its product portfolio by turnover products without expanding their portfolio diversification. Thus studies of the relation between diversification and firm performance should take product turnover activities into consideration. Overall, this data set is still limited in its scope of covering industries, but the empirical findings are rich with its moderate product classification and annual data.

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Figure 1: The Product Turnover Rate by Industries

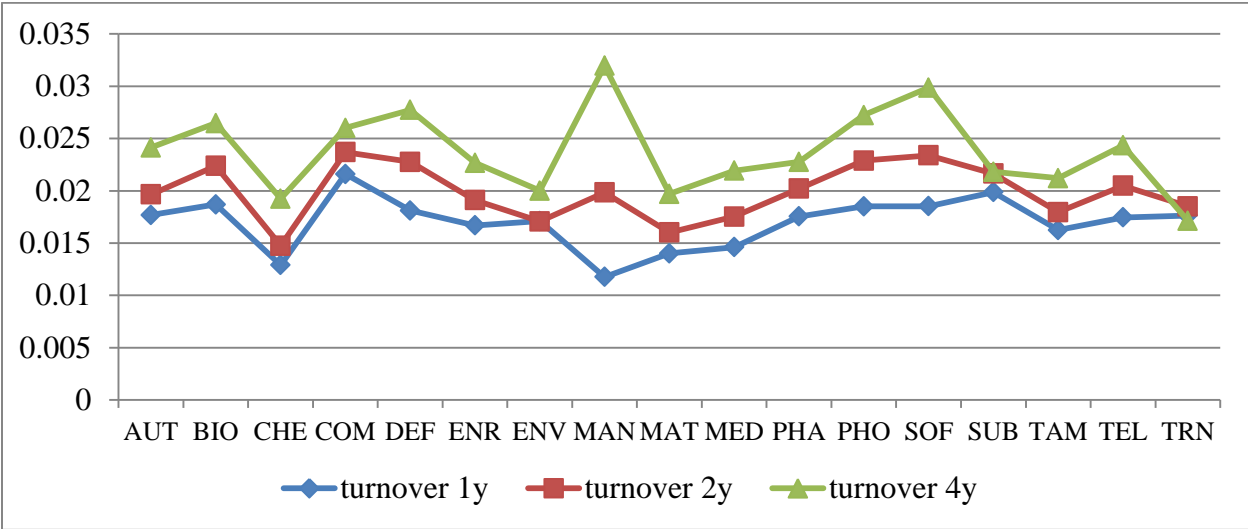
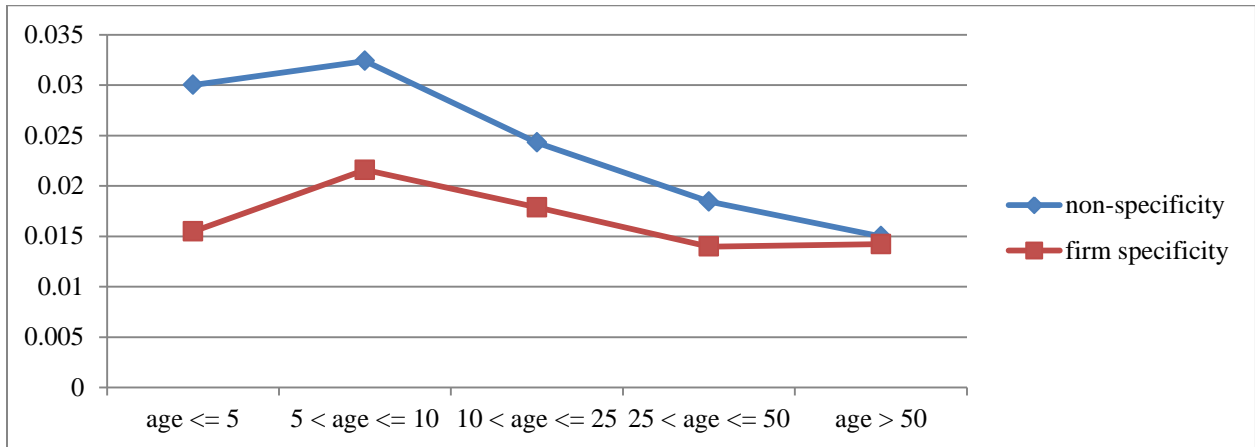
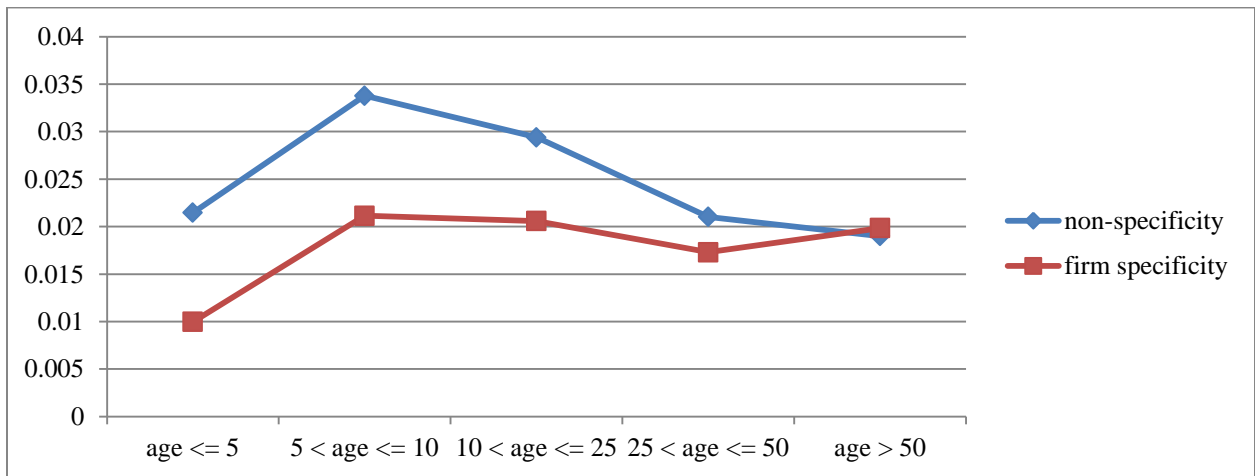


Figure 2: The Product Turnover Rate by Firm Age and Specificity

(a) 1-year turnover



(b) 2-year turnover



(c) 4-year turnover

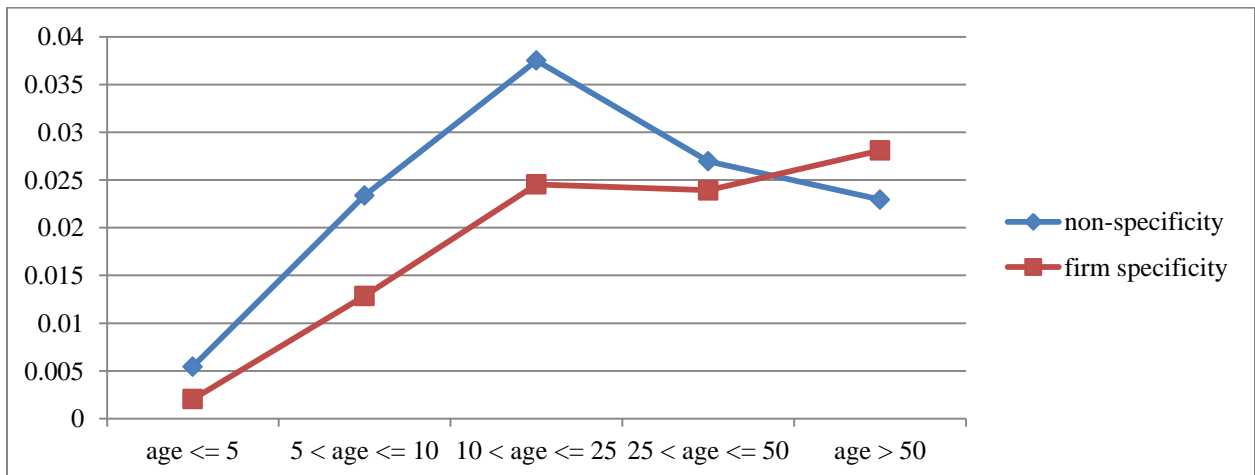


Figure 3: The Product Turnover Rate by Firm Sizes

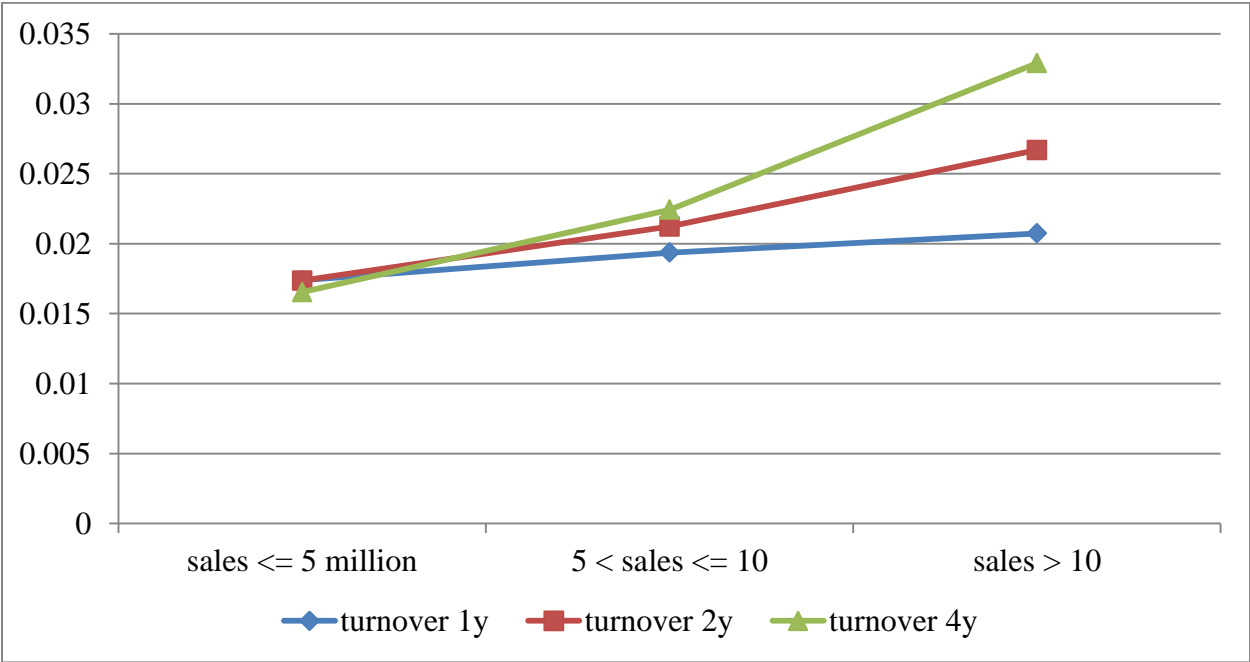
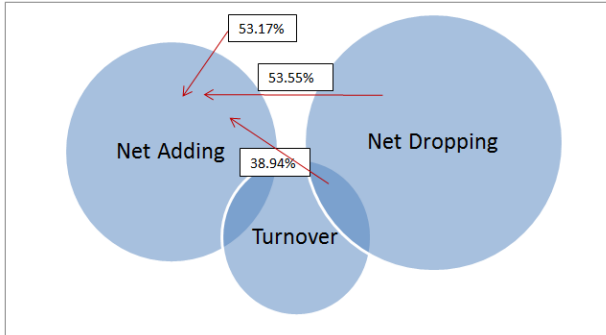


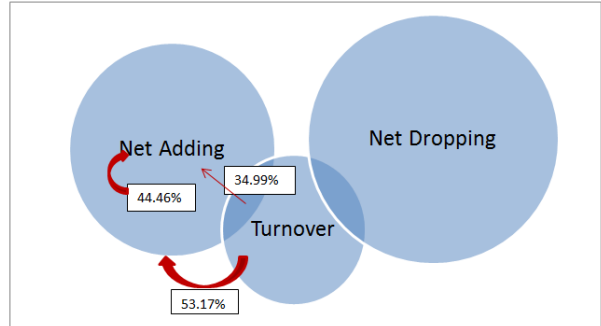


Figure 4: Transition of Firm Dynamics

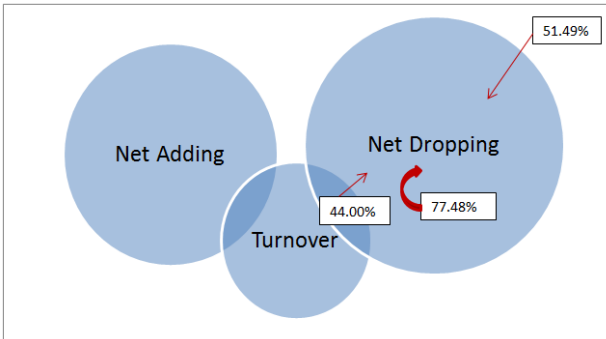
a. Conditional Transition from the Net-Dropping category



b. Conditional Transition from the Net-Adding category



c. Conditional Transition with 4-Year Time Window



d. Conditional Transition with 4-Year Time Window

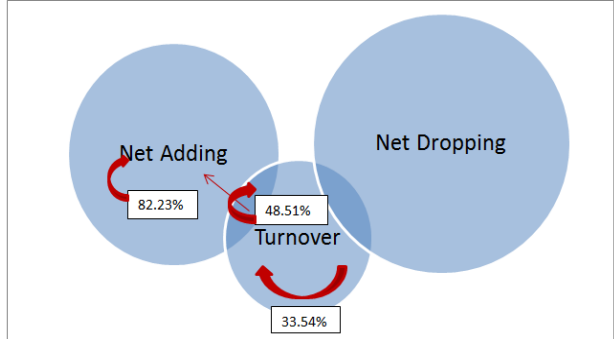
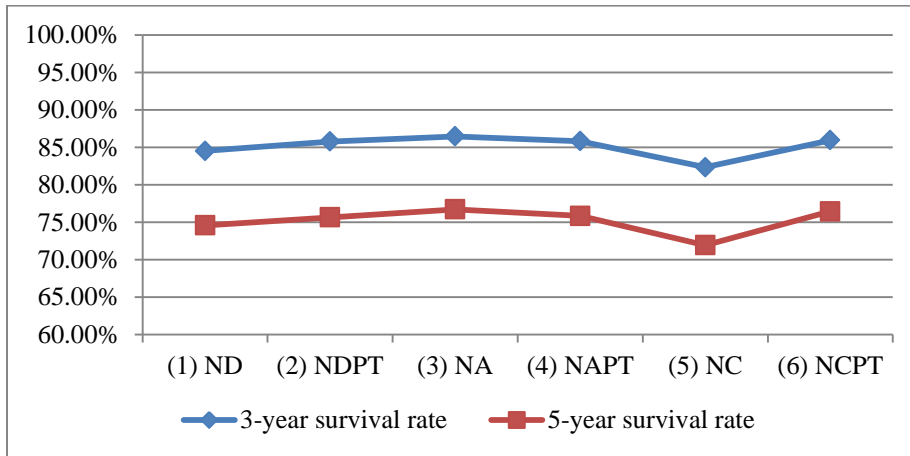
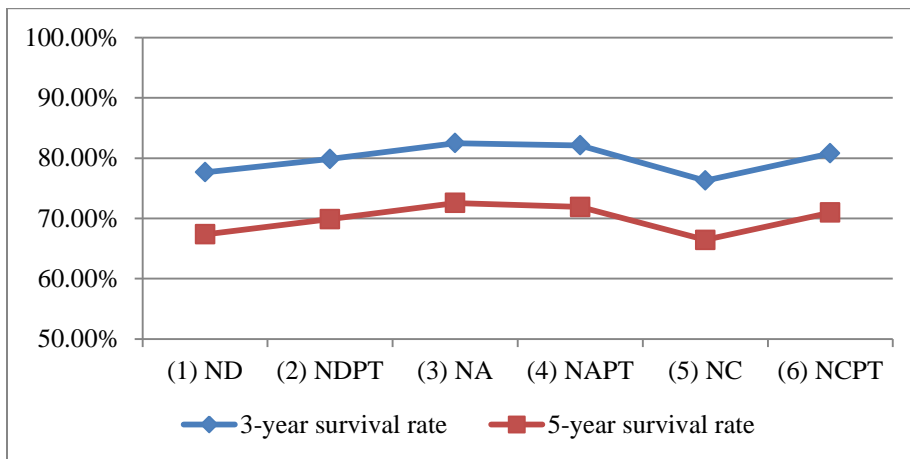


Figure 5: Firm Survival by Firm Dynamics Activities

(a) 1-year time window



(b) 2-year time window



(c) 4-year time window

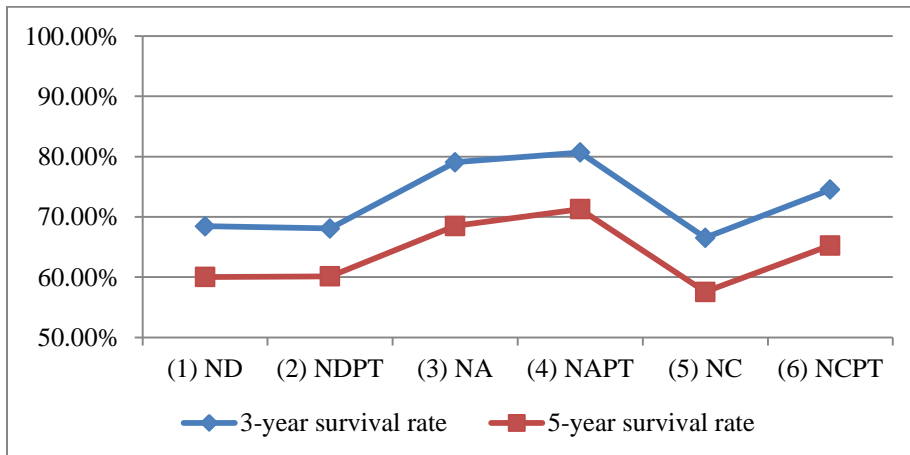


Table 1: Patterns of Percentages of Six Firm Dynamics Categories.

(a) 1-Year Time Window

Year	NetDrop		NetAdd		No change in Diversity Level		Total observations
	(1) ND	(2) NDPT	(3) NA	(4) NAPT	(5) NC	(6) NCPT	
1990	6.47%	3.41%	10.28%	4.91%	66.15%	8.78%	13,230
1991	5.41%	2.94%	15.11%	4.91%	64.13%	7.50%	16,570
1992	4.66%	2.40%	13.03%	2.97%	71.98%	4.96%	18,347
1993	2.39%	0.63%	7.01%	1.14%	87.15%	1.68%	18,709
1994	2.94%	1.00%	10.07%	1.98%	81.44%	2.57%	20,884
1995	4.33%	1.42%	12.11%	2.79%	75.81%	3.55%	24,369
1996	4.72%	1.65%	11.14%	2.99%	75.19%	4.31%	26,166
1997	4.76%	1.25%	9.32%	2.23%	79.24%	3.20%	27,165
1998	5.90%	1.15%	7.12%	3.57%	79.35%	2.90%	27,644
1999	3.56%	0.73%	7.86%	1.11%	85.39%	1.36%	30,399
2000	2.33%	0.42%	5.07%	0.68%	90.77%	0.72%	31,331
2001	3.85%	0.65%	5.99%	1.00%	87.74%	0.78%	34,631
2002	5.25%	0.90%	6.60%	1.18%	85.07%	1.00%	38,136
2003	4.61%	0.56%	6.58%	0.91%	86.57%	0.78%	36,735
2004	2.89%	0.27%	5.03%	0.50%	90.93%	0.38%	37,138
Total	4.18%	1.09%	8.19%	1.88%	82.28%	2.38%	401,454

(b) 2-Year Time Window

Year	NetDrop		NetAdd		No change in Diversity Level		Total observations
	(1) ND	(2) NDPT	(3) NA	(4) NAPT	(5) NC	(6) NCPT	
1992	15.58%	4.60%	22.53%	7.62%	42.16%	7.51%	16,628
1993	15.17%	4.29%	16.38%	3.95%	54.58%	5.65%	18,063
1994	13.20%	1.83%	15.92%	2.58%	63.82%	2.65%	18,510
1995	6.74%	1.28%	22.50%	3.39%	63.48%	2.61%	20,336
1996	9.65%	2.08%	21.62%	4.51%	58.67%	3.46%	24,394
1997	12.75%	2.97%	17.42%	4.39%	58.24%	4.23%	26,088
1998	15.38%	2.43%	14.01%	3.45%	61.04%	3.69%	26,368
1999	17.28%	2.03%	11.81%	3.72%	62.68%	2.48%	27,742
2000	13.57%	1.39%	10.14%	2.03%	71.34%	1.53%	30,985
2001	10.29%	0.81%	9.94%	1.21%	76.88%	0.87%	30,160
2002	15.30%	1.01%	11.40%	1.35%	70.10%	0.83%	33,711
2003	19.55%	1.31%	10.05%	1.54%	66.63%	0.92%	39,532
2004	15.91%	1.02%	8.74%	1.30%	72.13%	0.90%	37,868
Total	14.47%	1.86%	13.74%	2.81%	64.65%	2.45%	351,343

Table 2: Key Summary Statistics by Firm Dynamics Activities

	(1) ND	(2) NDPT	(3) NA	(4) NAPT	(5) NC	(6) NCPT	(7) Total
Product Count	5.65 (8.58)	11.45 (22.61)	7.32 (8.72)	14.10 (25.03)	3.50 (3.44)	5.13 (8.73)	4.21 (6.44)
Sales	616.55 (5177)	1883.12 (9664)	743.74 (34518)	1841.58 (10359)	100.86 (1842)	333.68 (3023)	229.17 (10295)
Firm Age	26.30 (25.97)	27.39 (29.17)	24.53 (24.70)	25.70 (28.01)	23.01 (21.00)	22.30 (21.87)	23.31 (21.77)
Sales per Product	68.19 (692)	86.25 (764)	56.65 (1751)	52.94 (325)	26.25 (419)	37.74 (483)	31.54 (655)
Percentage of Multi-division Firms	27.62%	37.97%	41.48%	40.84%	14.32%	20.95%	

*Note:* Standard errors in parentheses.

Table 3: Transition Probability Matrix of Firm Dynamics with 1-Year Time Window

Category		1	2	3	4	5	6	Total
ND	1	4.88	1.77	14.24	2.76	73.41	2.94	100
NDPT	2	6.64	5.09	14.28	6.24	63.33	4.42	100
NA	3	7.24	2.09	13	3.24	70.76	3.68	100
NAPT	4	7.69	5.21	14.2	8.58	59.42	4.91	100
NC	5	2.5	0.72	7.04	1.2	86.76	1.79	100
NCPT	6	4.9	1.98	11.16	3.24	74.35	4.37	100
	Total	3.22	1.05	8.15	1.7	83.71	2.16	100