Business Dynamics and Productivity Growth with an Application to Taiwanese Electronics Firms

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Abstract

Empirical progress on understanding the consequences of various sorts of business dynamics -- whether from a technological change, job creation and destruction, or firm governance and management perspective -- requires reliable ways of characterizing business dynamics and of measuring the impacts of various sorts of business dynamics on business and industry and national productivity growth. We review the literature on characterizing and on measuring the impacts of business dynamics on productivity growth. We introduce the business dynamic status categories used in virtually all of the studies of others: classifications of continuing, entering and exiting. This classification can be implemented with just two periods of data. We also propose an alternative dynamic classification for businesses utilizing three periods of data. For the empirical portion of this paper, like many others, we adopt the basic approach of Foster, Haltiwanger and Krizan. We implement this decomposition using data for Taiwanese electronics firms. We first use the conventional dynamic status classification approach for firms and then use our suggested new FNN approach. We demonstrate the value of the FNN classifications.

1. Introduction

> "A wave of innovation across a broad range of technologies, combined with considerable deregulation and a further lowering of barriers to trade, fostered a pronounced expansion of competition and creative destruction."
>
> Alan Greenspan, Speech on Economic Volatility, 2002.

Technological advances are widely viewed as an engine of economic growth. Moreover, new businesses are viewed by many as playing a key role in realizing the economic growth potential of new technologies. The presumed interrelationships of new technologies, new businesses and economic growth are one main reason for intense interest in the dynamic birth, growth and death cycles of businesses.[1]

Schumpeter (1942, p. 83) coined the term, "creative destruction," which he described as follows:

> "The fundamental impulse that keeps the capital engine in motion comes from the new consumers' goods, the new methods of production and transportation, the new markets.... [The process] incessantly revolutionizes from within.... This process of Creative Destruction is the essential fact of capitalism.

Others refer to this same sort of process as the natural selection mechanism (NSM) of economic Darwinism (e.g., Nishimura, Nakajima and Kiyota 2005).

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[1] For example, an MIT commission report suggests that establishments at the top of the productivity distribution rest on their laurels and lose their competitive advantage. See Caves and Barton (1990).

Employment issues are a second reason for intense interest in firm dynamics. Growing businesses create jobs. It is also true, of course, that growing businesses often take market share from other businesses, leaving the employees of those others businesses with lower earnings or unemployed. However, in countries open to trade, consumers can abandon domestic producers for the products of foreign competitors. Thus many of those who care deeply about maintaining and improving domestic employment opportunities nevertheless feel strongly that established businesses should not be shielded from the competition resulting from new entrants and the growth of other established businesses.

In an influential paper in the macroeconomics literature, Caballero and Hammour (1994) state that industries undergoing continuous creative destruction can accommodate variations in demand in two ways: “they can vary either the rate at which production units with new techniques are created or the rate at which units with outdated techniques are destroyed.” However, “industries” are not the decision makers for businesses. Businesses are created and developed and closed by the choices of managers and investors in their interrelated efforts to foresee, shape and respond to changing product demand and input supply conditions. Some of those who believe that business management and governance matter strive to extract yet another sort of lesson from research on business dynamics. They are interested in trying to understand how firms can be governed and managed over time so they will *continue* to be successful.

Empirical progress on understanding the consequences of various sorts of business dynamics -- whether from a technological change, job creation and destruction, or firm governance and management perspective -- requires reliable ways of characterizing business dynamics and of measuring the impacts of various sorts of business dynamics on business and industry and national productivity growth. It is the literature on characterizing and on measuring the impacts of business dynamics on productivity growth to which we turn our attention in section 2.

In the case of information technology (IT) goods such as computers, there has been an ongoing proliferation of new goods, and IT products have been improving in terms of functionality and dropping in price faster than other consumer and producer goods. As Hayashi and Nomura (2005) explain, the situation with IT goods raises problems for as well for the measurement of the output and input aggregates that are needed for measuring productivity at all levels of aggregation and for macroeconomic models. We gloss over these problems in this study and focus instead on the definition of the firm dynamics states: an issue the must be faced no matter how productivity is measured. In section 3 we introduce the business dynamic status categories that are used in virtually all of the studies reviewed in section 3: classifications of continuing, entering and exiting businesses that can be implemented with just two periods of data.

As the literature review in section 2 indicates, a number of different ways have been proposed for factoring productivity growth into components associated with the productivity growth of these businesses, including shifts in input utilization and market share among continuing businesses, and with business births and deaths. The productivity decomposition used in the empirical part of this study is introduced in section 4. In section 5, we propose an alternative dynamic classification for businesses utilizing three periods of data. In section 6, we use both the conventional and our new FNN business dynamic status classifications in analyzing data for Taiwanese electronics firms. We demonstrate the value of the FNN classifications. Section 7 concludes.

2. Lessons from the Literature

The empirical study of business dynamics got its start with the development of data sets that permit the tracking over time of business establishments or firms. Here we review some of the milestone studies, with special attention to the business dynamics status groups that are defined and findings that relate to these definitions.

2.1 Pioneering Studies

Baldwin and Gorecki (1991) use establishment based data for Canada, together with individual establishment and firm identifiers,[2] for the 1970s and early 1980s. In this study, the appearance of a new identifier defines a birth. The disappearance of an identifier from the universe of all establishment identifiers defines an establishment death. BG focus on the size of entrants at birth and their subsequent transition paths. Distinctions are made between greenfield (i.e., completely new) and merger entries.

Establishments under common ownership are linked together into aggregates that can be thought of as virtual firms. BG note that exit rates, calculated at, say, the individual four-digit industry level, are not be the same as for the manufacturing sector as a whole, since an establishment may leave one manufacturing industry for some other industry, which BG term a switch or a transfer. Entry rates defined for the manufacturing sector as a whole will not include establishment switches that take place between industries. The list of dynamic states defined and constructed in this study includes births, deaths, continuing, transfers, acquisitions, or divestitures.

Bresnahan and Raff (1991) (BR) use U.S. panel data for a period of great economic change to try to gain further insight into how establishment dynamics affect changes in productivity. In the United States during the Great Depression, half the establishments, and more than half the firms, in the motor vehicle industry closed between the 1929 peak and the 1933 trough.[3] By exploiting the panel feature of their data for auto industry establishments, BR are able to explore differences among closing, continuing,

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[2] These identifiers stay with business units over their lifetime.

[3] Okazaki (2008) documents the adjustments in another time and place of great economic upheaval: the textile industry over the years of 1894-1924 in Japan.

and newly started establishments: differences that BR find are large and systematic. They find that closures accounted for almost one-third of the decline in industry employment. Labor productivity appears also to have fallen at continuing establishments. The following upturn was largely accomplished by expansions of existing establishments and firms.

Baily, Hulten and Campbell (1992) (BHC) use data for 1972-1988 from the Longitudinal Research Database (LRD) developed by the U.S. Census Bureau. For any given year t, BHC note that some of the establishments operating in t will also have been operating in the prior period. These establishments are designated the “stayers” by BHC. Some of the establishments operating in t will have entered between the previous and current time periods. Some establishments operating in the prior period are no longer operating in t. They exited the industry. BHC decompose industry productivity growth into the contributions of stayers, entrants, and exits. They also try to ascertain how much of overall growth is from the establishments with particular sorts of productivity growth patterns, such as those that managed to stay on top in terms of productivity performance for prolonged periods of time.

BHC identify a positive contribution to growth from increasing output shares among higher productivity establishments and decreasing output shares among lower productivity establishments. This dynamic shifts an industry toward a higher productivity average. Old establishments are found to be only slightly less productive than are more recent ones. BHC find evidence consistent with the notion of well managed establishments that are able to stay on top for long periods. Establishments that are part of higher productivity firms also are found to have higher contemporaneous productivity. Establishments in firms with more rapid productivity growth grow more rapidly too.

Entry and exit are reported to play a relatively small role in industry productivity growth over time. BHC find that the majority of the entrants and exits are very small establishments, and a typical entering establishment -- like the typical exiting establishment -- is found to have productivity that is well below average. The smaller and less productive entering establishments are found to have quite high probabilities of exiting quickly.

Griliches and Regev (1995) (GR) examine panel data for firms for the years of 1979-1988 assembled by the Israeli Central Bureau of Statistics. For the three subperiods of 1979-82, 1982-85, and 1985-88, GR estimate the productivity impacts of continuing firms (those present at both the beginning and the end of the period), those that ‘closed’ (exited), and those that ‘opened’ (entered) by the end of the period. They ask how much of the growth in average productivity occurs within firms and how much is the result of the mobility of resources between them, both as a result of exit and entry and also as a consequence of the differential growth of surviving firms. GR find too that firms that can be seen from the data to exit in the future have lower productivity performance years prior to when they exit.

Nevertheless, GR conclude that most of the changes in aggregate productivity come from changes within firms rather than from different exit and entry rates and various weight shifts. Griliches and Regev (1995, p. 201) write:

> "In spite of the large amount of turnover and churning in firms and jobs, most of the productivity growth occurred within firms. Productivity growth in industry as a whole did not come primarily from the exit of failing firms or from the faster growth of more productive firms. What happened within firms was decisive and that is what needs attention...."

Haltiwanger (1997) uses data from the U.S. Longitudinal Research Database (LRD). Haltiwanger presents decomposition results for labor productivity based on both gross output and value-added measures. He notes that the measurement of labor productivity (particularly on a gross output basis) is less fraught with measurement problems than measures of total factor productivity (TFP). Haltiwanger finds that quite similar results are generated when using output weights as share weights in the decomposition, but with establishment level productivity measured in terms of labor productivity. An employment weighted decomposition of labor productivity yields roughly similar results too.

Haltiwanger reports that the shift in output towards establishments that are also increasing productivity is a major factor in accounting for the average industry productivity change, but that net entry plays an important supporting role as well.

Foster, Haltiwanger and Krizan (2000/2001) (FHK) use U.S. Census of Services establishment-level data for 1987 and 1992. They find that the impact of net entry is disproportionate since entering establishments tend to displace less productive exiting establishments, even after controlling for overall average growth in productivity. FHK also find that the gap between the productivity of entering and exiting establishments increases as the horizon over which the changes are measured increases.

2.2 Important Post 2000 Studies[4]

Nishimura, Nakajima, Kiyota, Minetaki, Tamai, and Kurokawa (2004) (NNKMTK) and also Nishimura, Nakajima and Kiyota (2005) (NNK) set out to investigate whether the natural selection mechanism of economic Darwinism works in severe recessions. They use data from the Basic Survey of Japanese Business Structure and Activities (BSJBSA) conducted by the Japanese Ministry of Economy, Trade and Industry (METI). This survey covers all commercial firms with 50 employees or more and capitalization of over 30 million yen that are at least partly engaged in mining, manufacturing, wholesale and retail sales, and restaurant activities. Nishimura and his collaborators analyze the entry/exit behavior of Japanese firms during the 1990s and find that relatively efficient firms exited while relatively

[4] Another interesting alternative decomposition is presented by Diewert and Fox (2009). We do not include their study in this section, however, because their only empirical results are for synthetic data.

inefficient firms survived during the banking-crisis period of 1996–1997. They conclude that the natural selection mechanism (NSM) malfunctioned during the severe 1996-1997 recession. They discuss various reasons why this malfunction might have occurred.

One empirical finding of this study is that efficient firms in terms of TFP exited while inefficient ones survived in the banking-crisis period of 1996-1997. Further, this phenomenon is observed mainly for new entrants and contributes substantially to a fall in macro TFP after 1996. These facts strongly suggest a malfunctioning of NSM in severe recessions.

They examine the dynamics of Japanese information service industries. They use the data from the *Survey of Selected Service Industries*, *Volume of Information Service Industries*, conducted by the Ministry of Economy, Trade and Industry (METI).

In these studies, firm entry is defined as the appearance of a new firm identification code or the reappearance of an old code. Either temporary or permanent disappearance of an identification code is defined as a firm exit. Continuing firms are defined as those with present identification codes for at least two consecutive years. The author notes that without these procedures, it would be difficult to construct TFP measures consistently for all firms. Firms that switch-in or switch-out for an industry are also identified.

Nishimura and his collaborators note that in popular terminology, “exit” means the complete closure of a business. However, according to this definition, “dormant” firms with no significant business that are still not closed are classified as continuing firms. The authors explain that in Japan there are a sizable number of “dormant firms” existing simply for tax-shelter and/or other purposes, although it is very difficult to determine the number of such dormant firms. In the economic analysis of productivity, we are concerned not with dormant firms, but with “active” firms. In this respect, entry and exit numbers presented in previous studies, based on *Company Statistics* and the like, are probably misleading because of dormant firms. In contrast, in the BSJBSA, the criteria of including firms with 50 employees or more and a capitalization in excess of 30 million yen mean that the included firms are likely to be “active.”

Fukao and Kwon (2005) (FK) also use firm-level panel data for 1994-2001 from the BSJBSA. They decompose TFP growth in the manufacturing sector into a within-firm effect, a reallocation effect, and an entry-exit effect. FK find that both the exit effect (excluding the switch-out effect) and the switch-out effect for the manufacturing sector as a whole from 1996 to 2001 were negative and contributed to the decline in TFP growth in the manufacturing sector. They find also that both the entry effect (excluding the switch-in effect) and the switch-in effect were positive in almost all the industries. Moreover, the entry effect (including the switch-in effect) was positive in both the upturn and the downturn periods. But probably as a result of the low entry rate, the size of the entry effect was not large. FK find that the redistribution effect – that is, the between effect plus the covariance effect – was positive. And, they find that the within effect, i.e. the effect of TFP growth within staying firms, was the largest factor among all the effects. Moreover, this effect changed pro-cyclically.

Brown and Earle (2008) (BE) assemble comparable annual panel data with long time series on of manufacturing firms in six of these economies – Georgia, Hungary, Lithuania, Romania, Russia, and Ukraine. They use these data to measure the contribution of inter-firm employment reallocation to aggregate productivity growth during the socialist and reform periods in six transition economies. BE find that reallocation rates and productivity contributions are very low under socialism. After reforms, they rise dramatically, and productivity contributions greatly exceed those observed in market economies. Early in transition, faster reform is associated with larger contributions from reallocation, but later, and on average over the whole transition, this relationship is reversed. Though reallocation rates are larger in faster reforming economies, higher productivity dispersion in slower reformers creates much higher productivity gains for a given volume of reallocation. The results imply that reallocation should be viewed as necessary regular maintenance for a well-functioning economy, and particularly large productivity contributions tend to reflect previous neglect more than current virtue.

BE argue that the conventional measures of the contributions of entry and net entry of previous studies are difficult to interpret, since they are highly sensitive to the share of new entrants and trend productivity growth. They address this problem by decomposing the standard entry term into proportionate and disproportionate entry, and the latter is useful for evaluating entry's contribution. The results from the decomposition into proportionate and disproportionate entry show that entrants' productivity is actually lower on average than that of surviving incumbents in several of the countries, particularly when using shorter decomposition periods. By calculating separate disproportionate entry terms for each entry cohort within the decomposition period, they show that the terms for disproportionate entry of all cohorts together are dragged down by the most recent cohorts.

Carreira and Teixeira (2008) (CT) examine data drawn from an annual business survey run by the Portuguese Statistical Office (INE). The sample of manufacturing firms comprises some 1,900 units, observed over a 10-year period (1991–2000, unbalanced panel). This paper decomposes the productivity growth into four components—within, between, cross, and net entry, as suggested by Foster et al. (2001) and Griliches and Regev (1995)—and discusses the cyclical pattern of internal versus external restructuring. The results of the decomposition of industry productivity growth suggest that the share of external restructuring is stronger in recession, while internal restructuring seems to be more dominant in expansions. CT conclude that in Portugal the competitive pressures on inefficient firms are inadequate in expansions.

Foster, Haltiwanger and Syverson (2008) (FHS) note that whereas it is true that businesses with higher measured productivity levels tend to grow faster and are more likely to survive, nevertheless, selection is actually on profitability rather than productivity. Productivity, of course, is only one of several factors that determine profits. they note that a limitation of empirical research with business microdata is that establishment-level prices are typically unobserved. Usually, establishment output must be measured as revenue divided by a common industry-level deflator. Therefore within-industry price differences are embodied in output and productivity measures. The connection between productivity and survival probability, reallocation, and industry dynamics may be overstated, and the impact of demand-side influences on survival understated.

FHS investigate the nature of productivity growth in industries where they can observe quantities and prices separately. They show that physical productivity is inversely correlated with price while revenue productivity is positively correlated. FHS find that young producers charge lower prices than incumbents. One implication of their findings is that the literature understates new producers' productivity advantages and entry's contribution to aggregate productivity growth. Their estimates also suggest that demand variations across producers are the dominant factor in determining survival.

3. A Conventional Dynamic Status Classification of Businesses Using Two Periods of Data

In the studies of others, business dynamics status groups have usually been defined with respect to the universe of businesses present in one or the other or both of two time periods. Letting S^{t-1} denote the set of all businesses present in $t-1$ and letting S^{t} denote the set of all businesses present in t, the universe of businesses present in $t-1$ or t can be represented as

(3-1) $U(t-1,t) = S^{t-1} \cup S^{t}$.

Businesses present in both $t-1$ and t are referred to as continuing (C). We denote the set of these businesses by S_C and their number by N_C. Businesses present only in the second of the two periods are referred to as entering (E). We denote the set of these businesses by S_E and their number by N_E. Finally, we refer to businesses present in only the first of the two periods as exiting (X). The set of all these businesses is denoted by S_X and their number by N_X. Note that among all of the businesses present in $t-1$ or t, it is only the businesses classified as continuing for which t minus $t-1$ difference variables can be defined. Note that the period t firms are thus all either classified as continuing or entering, and the period $t-1$ firms are all either classified as continuing or exiting.

The conventional definitions and notations for the business dynamics status sets defined above are shown for convenience in table 1.

Table 1. Conventional Definitions for Turnover Status Variables

Symbol for status	Symbols for the sets and numbers of businesses in $U(t-1,t)$ by dynamics status	Name for status	Definition of status
C	S_C, N_C	Continuing in $t-1$ and t	Present in both $t-1$ and t
E	S_E, N_E	Entering in t	Present in t but not $t-1$
X	S_X, N_X	Exiting in $t-1$	Present in $t-1$ but not in t

4. Decomposition Specifics for This Study

4.1 Within Group, and Group and Business Unconditional, Share Parameters

For the purpose of defining performance measures for various groupings of the stated universe of businesses and for the universe as a whole, it is common for researchers to define *share parameters*. These could be shares of revenue, shares of costs, or some other sort of shares. Foster, Haltiwanger and Syverson (2008) assert that the choice of weight is "an open question". The most common choices are either output (or revenue) weight or employment weight.

Within group shares are the first type of share parameter we define. We denote the period t share for business i in group g relative to all businesses in group g by $\theta^t_{i|g}$. Group shares are the second type of share parameter we define. We denote the period t share of all businesses in group g relative to all businesses in the given universe by θ^t_g. Shares for individual businesses relative to the universe are the third type of share parameter we define. We denote the share for business i relative to all businesses present in the universe by θ^t_i.

If S_g denotes the set of all businesses in group g, then the following conditions must be satisfied for the three types of share parameters:

(4-1) $$\sum_{i\in S_g} \theta^t_{i|g} = 1, \quad \sum_{\text{All } g} \theta^t_g = 1; \text{ and } \sum_{i=1}^{N} \theta^t_i = 1.$$

Note too that the three sorts of share parameters defined here are related as follows for any choice of values for i, g and t:

(4-2) $$\theta^t_{i|g} \times \theta^t_g = \theta^t_i.$$

We now let Π_i^t denote some given period t firm performance level measure that can be computed for every firm present in period t. Once Π_i^t has been defined, now we can define a period t performance level measure for the businesses in some set g as

(4-3) $$\Pi_g^t \equiv \sum_{i \in S_g^t} \theta_{i|g}^t \Pi_i^t \text{ for all g.}$$

Also, we can define a performance level measure for the N businesses present in the universe by $U(t-1,1)$ by:

(4-4) $$\Pi^t \equiv \sum_{\text{All g}} \theta_g^t \Pi_g^t$$

(4-5) $$= \sum_{\text{All g}} \theta_g^t \Big(\sum_{i \in S_g^t} \theta_{i|g}^t \Pi_i^t \Big)$$

(4-6) $$= \sum_{i=1}^{N} \theta_i^t \Pi_i^t .$$

4.2 The Productivity Decomposition Used in Our Empirical Analysis

We follow Foster, Haltiwanger and Krizan (2000/2001) (FHK), Foster, Haltiwanger and Syverson (2008), Carreira and Teixeira (2008) and others in adopting the FHK modification of the decomposition proposed by Baily, Hulten, and Campbell (1992) (BHC). Continuing, entering and exiting firms are compared to aggregate productivity in the initial year (*t-1*).

(4-1) $$\begin{aligned} \Delta\Pi^t = & \sum_{i \in S_C} \theta_i^{t-1} \Delta\Pi_i^t + \sum_{i \in S_C} \Delta\theta_i^t (\Pi_i^{t-1} - \Pi^{t-1}) + \sum_{i \in S_C} \Delta\theta_i^t \Delta\Pi_i^t \\ & + \sum_{i \in S_E} \theta_i^t (\Pi_i^t - \Pi^{t-1}) - \sum_{i \in S_X} \theta_i^{t-1} (\Pi_i^{t-1} - \Pi^{t-1}) \end{aligned}$$

where $\Delta x^t = x^t - x^{t-1}$. The first component on the right hand side of equation (4-1), $\sum_{i \in S_C} \theta_i^{t-1} \Delta\Pi_i^t$, represents productivity improvement of continuing firms (holding share constant at the initial level), and it is known as the within firm effect. The second component, $\sum_{i \in S_C} \Delta\theta_i^t (\Pi_i^{t-1} - \Pi^{t-1})$, represents the change of shares (holding productivity constant) and it is known as the between-firm effect. The third component, $\sum_{i \in S_C} \Delta\theta_i^t \Delta\Pi_i^t$, is the cross effect. The fourth and fifth components represent the contribution of entry and exit to productivity growth. Here, the initial aggregate productivity (Π^{t-1}) is used as the reference point. Firm entry is considered contribute positively to productivity growth if the entrants are more productive as compared to the initial average. Similarly, exits are considered contribute positively to productivity growth if the exits are less productive as compared to the initial average.

5. Rethinking the Conventional Dynamic Status Classifications for Companies

Notice that the conventional classification system (which is all that is possible with only two periods of data) provides no way of distinguishing a key group of businesses: those that fail within one period of entering. Even if the data periods are consecutive years, the percentage of businesses that enter one period and are already gone again by the next can easily be 20 percent or more even in good economic times. In a recession, or when the data periods are multiple years wide, or multiple years apart, the percentage of businesses that enter one period and are already gone again by the next can easily exceed half. Data permitting, it thus seems preferable to define business dynamic status states based on three rather than two periods of data.

Consider the three periods of data denoted by $t-1$, t and $t+1$. Businesses present in $t-1$, t and also $t+1$ will be referred to as *continuing survivors* in period t (CS^t). The set of these businesses is S_{CS}^t and the number of them in period t is denoted by N_{CS}^t. Businesses not present in $t-1$, but present in t and $t+1$ will be referred to as *entering survivors* in period t (ES^t). The set of these businesses is S_{ES}^t and the number of them in period t is denoted by N_{ES}^t. Businesses not present in $t-1$, present in t, and then absent again in $t+1$ will be referred to as *entering failures* in period t (EF^t). The set of these businesses is S_{EF}^t and the number of them in period t is denoted by N_{EF}^t. Finally, businesses present in $t-1$ and in t, but absent in $t+1$ will be referred to as *exiting survivors* in period t (XS^t). The set of these businesses is S_{XS}^t and the number of them in period t is denoted by N_{XS}^t. Note that all of the businesses present in t (denoted by S_S^t) fall into one, and at most one, of the sets S_{CS}^t, S_{ES}^t, S_{EF}^t and S_{XS}^t. That is, these sets are mutually exclusive and they are also exhaustive if the universe of interest is taken to be all businesses in existence in period t. The details for our proposed FNN categorization are shown, for convenience, in table 2.

Table 2. FNN Turnover Status Variables for Period t

Symbol for status	Symbols for the sets and numbers of businesses in $U(t-1, t, t+1)$ by dynamic status	Name for status	Definition of status
CS^t	S^t_{CS}, N^t_{CS}	Continuing survivor in t	Present in $t-1$, t and $t+1$
ES^t	S^t_{ES}, N^t_{ES}	Entering survivor in t	Absent in $t-1$, but present in t and $t+1$
EF^t	S^t_{EF}, N^t_{EF}	Entering failure in t	Absent in $t-1$, present in t, but absent again in $t+1$
XS^t	S^t_{XS}, N^t_{XS}	Exiting survivor in t	Present in $t-1$ and t but absent in $t+1$

Table 3 shows all possible sequences of being present and absent for a business in periods $t = 0,1,2,3$ and shows the results of applying first the conventional and then the HNN definitions turnover status definitions with the various possible sequences for a business being present and absent over four years for which data are available.

Table 3. The Conventional versus the FNN Definitions Applied

		Conventional definition based on two periods of data	**FNN definition based on three periods of data**	
	Possible sequences of present (P) and absent (A)	Status based on data for t=1 and t=2	Status in t=1 based on data for t=0, t=1 and t=2	Status in t=2 based on data for t=1, t=2 and t=3
	Continuing (C) based on conventional 2-period dynamic status definitions			
1	$P^0P^1P^2P^3$	C	CS^1	CS^2
2	$P^0P^1P^2A^3$	C	CS^1	XS^2
3	$A^0P^1P^2P^3$	C	ES^1	CS^2
4	$A^0P^1P^2A^3$	C	ES^1	XS^2
	Entering (E) based on conventional 2-period dynamic status definitions			
5	$P^0A^1P^2P^3$	E	---	ES^2
6	$A^0A^1P^2P^3$	E	---	ES^2
7	$P^0A^1P^2A^3$	E	---	EF^2
8	$A^0A^1P^2A^3$	E	---	EF^2

	Exiting (X) based on conventional 2-period dynamic status definitions			
9	$P^0P^1A^2A^3$	X	XS^1	---
10	$P^0P^1A^2P^3$	X	XS^1	---
11	$A^0P^1A^2P^3$	X	EF^1	---
12	$A^0P^1A^2A^3$	X	EF^1	---
	Not present in either of the two designated periods			
13	$P^0A^1A^2P^3$	--	---	---
14	$P^0A^1A^2A^3$	--	---	---
15	$A^0A^1A^2P^3$	---	---	---
16	$A^0A^1A^2A^3$	---	---	---

6. A Decomposition of Firm Dynamic Effects on Electronics Industry Productivity in Taiwan

The story of how Taiwan was transformed into a technically advanced, relatively wealthy newly-industrialized economy has been much studied. From the early 1980s on, the Taiwanese government began to focus on the strategic development of high-tech, high value-added and energy-efficient industries. Semiconductors are the backbone of the Taiwanese electronics industry.

Almost all of Taiwan's semiconductor industry is located in the Hsinchu Science-Based Industry Park, which also houses the country's leading computer establishments including Acer. Hsinchu was designed and launched and nurtured by the Taiwanese government following the model of California's Stanford Research Park. Hsinchu Park also includes a government research institute (ITRI), and two of Taiwan's most significant technical universities (Chiaotung and Tsing Hua). The government-owned Park offers firms that settle there attractive terms for setting up a business, as well as a range of taxation benefits and allowances, low-interest loans; R&D matching funds; tax benefits (e.g., investment allowances); and special exemptions from tariffs, commodity, and business taxes. Also, a firm that is accepted as a resident of Hsinchu Park stands a much greater chance by that fact alone of raising bank loans for investment.

Taiwan now acts as the technological gateway between the United States and China. Production networks composed of small and medium enterprises are an integral part of the Taiwan’s economic development miracle. Sturgeon (2002) explains that the production system for the computer and telecommunication industry is highly “modular.” Saxenian and Hsu (2001) explain that foundries arose first in Taiwan, as key firms in that country decided that their best strategy for becoming internationally competitive in the industry was to focus on perfecting the process technology and let others do the designs. These firms were founded or run by Taiwanese nationals who had been trained in the United States or who had worked for U.S. semiconductor firms previously. By now, a thriving electronics industry has been created in Taiwan. Mathews (1997) explains that by the mid-1990s, the industry had reached a level of output that placed it behind only the United States, Japan, and Korea.

6.1 Data Description

In the empirical analysis, we use data on Taiwanese electronics firms. The firm-level data are extracted from the Industry, Commerce, and Service Census for the Manufacturing Sector for the years of 1986, 1991, and 1996. This census is conducted every five years by the Directorate General of Budget, Accounting, and Statistics, Executive Yuan, Taiwan. The comprehensive coverage of firms makes it possible to trace firm turnover status by matching firm identification numbers over census years. The data set includes information on the starting year, number of employees, wages and salaries, materials, energy, fixed assets, subcontracting activity, revenue, domestic sales and exports. Firm productivity is constructed by using a multilateral index number approach with output being measured as revenue deflated by an industry price index (see appendix A).

The micro data on electronics firms used for our empirical analysis is well-documented in previous studies such as Aw (2002), Aw, Chen, and Roberts (2001), and Fung (2008). According to Fung (2008), the firm exit rate in the Taiwanese electronics industry was 43% between 1986 and 1991 and 30% between 1991 and 1996. We choose to focus on the electronics industries because it is an industry with rapid productivity growth, high rates of firm entry and exit, and quality variation in products.

This data set covers electronics firms in both the cross-sectional and time series dimensions, so that we can identify firm turnover status in these three census years. In addition, the starting year information makes it possible to further classify firms in operation in 1986 into firms that were in operation in 1981 (the last census year before the 1986 census) and firms that entered after 1981.
Next, we apply the FNN definition to firms present in 1986 and 1991. Based on the definition, firms that appeared in both 1986 and 1991 are the ones that were classified as continuing survivors and entering survivors in 1986 and as continuing survivors and exiting survivors in 1991. The firms that were in presence in 1986 but not in 1991 were the ones that were defined as exiting survivors and entrant failures in 1986. The firms in presence in 1991 but not in 1986 were the ones that were defined as entering survivors and entering failures in 1991.

Based on the available information, we are able to apply the FNN definition not only to 1991 but to 1986. Table 4 summarizes the share of firms and employment of firms in different turnover status based on the FNN definition. To sum up, continuing firms are disproportionately large. In 1986, continuing firms consisted of 26% of the firms and 56% of the total employment. The exiting continuing firms are much smaller. They consisted of 25% of the firms but only 23% of employment. In addition, the successful entrants are relatively larger as compared to the entrants that failed.

Table 4. Firm and Employment Shares of Firms in Different Turnover Status

		CS^{86}	XS^{86}	ES^{86}	EF^{86}
Firms		0.26	0.25	0.20	0.29
Employment		0.56	0.23	0.10	0.10
		CS^{91}	XS^{91}	ES^{91}	EF^{91}
Firms		.023	0.09	0.39	0.29
Employment		0.52	0.09	0.27	0.11

The firm level observations must be formed into groups to carry out a FHK type productivity decomposition. Table 5 shows how these groups can be formed for the conventional and for the FNN classification approaches.

Table 5. The FNN Dynamic Status Sets That Fall within Each Conventional Dynamic Status Group

Group (g)	**The sets defined using the FNN definitions that fall into each of the designated conventional dynamic status groups**
	Continuing (S_C) based on conventional2-period dynamic status definitions
1	$S_1^{1,2} \equiv S_{CS}^1 \cap S_{CS}^2$
2	$S_2^{1,2} \equiv S_{CS}^1 \cap S_{XS}^2$
3	$S_3^{1,2} \equiv S_{ES}^1 \cap S_{CS}^2$
4	$S_4^{1,2} \equiv S_{ES}^1 \cap S_{XS}^2$
	Entering (S_E) based on conventional 2-period dynamic status definitions
5	$S_5^{1,2} \equiv S_{ES}^2$
6	$S_6^{1,2} \equiv S_{EF}^2$
	Exiting (S_X) based on conventional 2-period dynamic status definitions
7	$S_7^{1,2} \equiv S_{XS}^1$
8	$S_8^{1,2} \equiv S_{EF}^1$

Table 5 shows the four sets, created using the FNN definitions, that fall into the conventional continuing category. The set $S_1^{1,2}$ consists of the firms that were continuing going into period 1, and that are continuing still following the second of the two designated periods for which the conventional groups are defined. In addition, we have the $S_2^{1,2}$ group of firms that will exit following the second of the two periods. We also have the $S_3^{1,2}$ firms that just entered prior to the first of the two periods. And we have the $S_4^{1,2}$ group consisting of firms that just entered prior to the first period and will exit following the second period. From table 5, we see also that the conventional group of entering firms includes both the FNN entering survivors that will continue on following the second period and the FNN entering failures that will exit following the second period. Finally, we see that the conventional group of exiting firms includes both the FNN firms that were continuing coming into the two periods and the firms that just entered and will be gone again by period 2.

Of course, the added complexity of the FNN classification is only worthwhile if more useful inferences result from using this classification. We now turn to the data and apply both the conventional and the FNN classifications.

6.3 Empirical Results

We can further explore the difference between continuing survivors, exiting survivors, entering survivors and entering failure by testing if their productivity indicators are different at the 5 percent significance level. The results are reported in Table 6. Firms in operation in 1986 can be grouped into conventional continuing firms -- firms that have been in operation since 1981 -- and firms that entered after 1981. The results in column 1 indicate that the conventional continuers are more productive compared to the conventional entrants. These results confirm that the contribution of these firms to the aggregate productivity growth should be examined separately. We can further categorize conventional continuers into continuing survivors (those survived to 1991) and exiting survivors (those stayed in 1986 but exited before 1991). Results in the first two rows of column 2 indicate that continuing survivors are significantly more productive as compared to the exiting survivors. Similarly, the general entrants can be classified into entering survivors and entering failures. Results in the bottom two rows of column 2 indicate that the entering survivors are significantly more productive as compared to the entering failures. Similar patterns are found for the firms in operation in 1991.

Table 6. Productivity Differentials

Firms in Operation in 1986				Firms in Operation in 1991			
Turnover Status (1981-86)	**Mean lnTFP**	**Turnover FNN Definition**	**Mean lnTFP**	**Turnover Status (1986-91)**	**Mean lnTFP**	**Turnover FNN Definition**	**Mean lnTFP**
	(1)		(2)		(3)		(4)
Conventional general continuing firms	-0.069	Continuing Survivors (CS)	-0.054	Conventional general continuing firms	0.165	Continuing Survivors (CS)	0.180
		Exiting Survivors (XS)	-0.084			Exiting Survivors (XS)	0.127
		Significantly Different at 5%?	Yes			Significantly Different at 5%?	Yes
Conventional general entering firms	-0.108	Entering Survivors (ES)	-0.093	Conventional general entering firms	0.163	Entering Survivors (ES)	0.175
		Entering Failure (EF)	-0.118			Entering Failure (EF)	0.147
		Significantly Different at 5%?	Yes			Significantly Different at 5%?	Yes
Significantly Different at 5%?	Yes			Significantly Different at 5%?	No		

Notes: The entrants between 1981 and 1986 are identified using the starting year information for firms that are in operation in 1986. lnTFP can be negative because it is expressed as a deviation from the mean in the base year.

We can apply the new definition to the FHK type of productivity decomposition. The classification of firms follows the last two columns of table 3. Take 1986 as t=1 and 1991 as t=2: two census years that we have enough information to define firm turnover status using the FNN definition. We can start with decomposing productivity growth using the two-period definition (continuing, C, exiting, X, and entering firms) based on the data for years 1 and 2. The productivity growth between year 1 and 2 can be decomposed as:

$$(6\text{-}1)\quad \Pi^2-\Pi^1=\sum_{i\in S_C}\theta_i^2(\Pi_i^2-\Pi^1)-\sum_{i\in S_C}\theta_i^1(\Pi_i^1-\Pi^1)+\sum_{i\in S_E}\theta_i^2(\Pi_i^2-\Pi^1)-\sum_{i\in S_X}\theta_i^1(\Pi_i^1-\Pi^1)$$

Recall that when the two period definition is applied, the continuing firms were defined as the firms that were in presence in both years 1 and 2. Using the three period definition, the general continuing firms can be further specified into four groups: (1) firms that were classified as continuing survivors in both year 1 and 2; (2) firms that were classified as continuing survivors in year 1 and exiting survivors in year 2; (3) firms that were classified as entering survivors in year 1 and continuing survivors in year 2; and (4) firms that were classified as entering survivors in year 1 and exiting survivors in year 2. In addition, the entering firms can be represented as two groups and the exiting firms as another two groups. In all, for the FNN classification, there are the eight groups summarized in table 5. By applying this more detailed definition, the first two elements on the right hand side of the equation above can be specified into:

(6-2) $$\Pi^2 - \Pi^1 = \sum_{g=1}^{8} [\sum_{i \in S_g^{1,2}} \theta_i^2 (\Pi_i^2 - \Pi^1) - \sum_{i \in S_g^{1,2}} \theta_i^1 (\Pi_i^1 - \Pi^1)] .$$

Further, following the FHK method, the growth of each group of firms that were observed in both periods (that is, for groups $g = 1, \ldots, 4$) can be further decomposed into the within-firm, between firm and cross firm components:

(6-3) $$\sum_{i \in S_g} \theta_i^2 (\Pi_i^2 - \Pi^1) - \sum_{i \in S_g} \theta_i^1 (\Pi_i^1 - \Pi^1) = \sum_{i \in S_g} \theta_i^1 \Delta \Pi_i^2 + \sum_{i \in S_g} \theta_i^2 (\Pi_i^1 - \Pi^1) + \sum_{i \in S_g} \Delta \theta_i^2 \Delta \Pi_i^2 ,$$

where $\Delta x^2 = x^2 - x^1$, and the S_g groups are defined as in table 5..

Table 7 summarizes results of productivity decomposition using the FHK approach with either the usual two period definition of entry, exit and continuing firms (equation number) and the FNN definition. The first row of Table 7 reports the results of productivity decomposition using the usual two period definition. As discussed in Section 4.2, when the FHK method is applied, the growth of continuing firms can be further decomposed into within-firm, between-firm and cross-firm components. The results indicate that the productivity growth of the Taiwanese electronic industry was primarily driven by the within-firm growth among continuing firms while the net entry of firms (i.e. exits being replaced by entrants) played a secondary but significant role.

The second to fourth rows of Table 7 report the results of further decomposition of the within, between and cross firm components into the contribution of firms in different turnover status using the FNN definition. The results indicate that among the continuing firms, their contribution to productivity growth is uneven. The within-firm growth is primarily attributable to the growth of firms that were classified as continuing survivors in both periods (i.e., firms that have been in operation in all the census years observed).[5]

[5] Using the two-period definition, there were 2,721 continuing firms, out of which 1,182 firms were classified as continuing survivors in both periods 1 and 2 and they account for 70% of the within firm growth.

Table 7. Productivity Decomposition using FHK Approach, 1986-1991

Total Growth		**Within**	**Between**	**Cross**	**Entrant**	**Exit**	**Net Entry**
(1)	=	(2)+	(3)+	(4)+	(5)+	(6)	(7) = (5)+(6)
25.59%		17.00%	1.03%	-2.26%	9.71%	0.11%	9.82%
	Firms present both periods (1986 and 1991)						
	$S_2^{1,2} \equiv S_{CS}^1 \cap S_{CS}^2$	11.76%	0.87%	-2.39%			
	$S_2^{1,2} \equiv S_{CS}^1 \cap S_{XS}^2$	2.17%	0.10%	-0.82%			
	$S_3^{1,2} \equiv S_{ES}^1 \cap S_{CS}^2$	2.05%	0.14%	0.79%			
	$S_4^{1,2} \equiv S_{ES}^1 \cap S_{XS}^2$	1.02%	-0.08%	0.16%			
	Firms present only in period 2 (1991)						
	$S_5^{1,2} \equiv S_{ES}^2$				6.93%		
	$S_6^{1,2} \equiv S_{EF}^2$				2.78%		
	Firms present only in period 1 (1986)						
	$S_7^{1,2} \equiv S_{XS}^1$					-0.24%	
	$S_8^{1,2} \equiv S_{EF}^1$					0.36%	

The sixth and seventh rows further decomposes the contribution of entry to the growth of entering survivors and the growth of entering failures. The results show that the entry of firms that eventually survived have a much greater contribution to the aggregate productivity growth as compared to the entrants that eventually failed. The last two rows further decompose the contribution of exits to productivity growth into the contribution of entering failures (in period 1) and exiting survivors. Interestingly, the entering failure contributes positively to productivity growth (i.e., they are less productive as compared to the average productivity in period 1) while the exiting survivors contribute negatively.

Table 8. Definition of Firm Turnover Status (A: Absent; P: Present)

	t = 0 (1981)	t = 1 (1986)	t = 2 (1991)	t = 3 (1996)
CS^{86}	P	P	P	
XS^{86}	P	P	A	
ES^{86}	A	P	P	
EF^{86}	A	P	A	
CS^{91}		P	P	P
XS^{91}		P	P	A
ES^{91}		A	P	P
EF^{91}		A	P	A

7. Concluding Remarks

Kui (2007) explains that the main countries involved in the Asian production networks are the United States, Japan, Korea, Taiwan, Hong Kong and Singapore. Taiwanese firms specialize in personal computer electronics and are said to be relatively open. Their adjustments to market conditions and technological shifts are claimed by analysts such as Dujarric and Hagiu (2009) to be more agile than their Japanese counterparts. In Japan, Korea and Taiwan, there is government support for small and medium sized enterprises in the IT and electronics industry. The SMEs in Taiwan have achieved a broad range of capabilities during 1990s and turned Taiwan into a world-class supply source for a variety of electronic hardware products. Also, the Taiwanese semiconductor industry is now the third largest in the world, after North America and Japan. There is a great deal of interest in this industry within and outside of Taiwan.

Empirical progress on understanding the consequences of various sorts of business dynamics -- whether from a technological change, job creation and destruction, or firm governance and management perspective -- requires reliable ways of characterizing business dynamics and of measuring the impacts of various sorts of business dynamics on business and industry and national productivity growth. We review the literature on characterizing and on measuring the impacts of business dynamics on productivity growth. We introduce the business dynamic status categories used in virtually all of the studies of others: classifications of continuing, entering and exiting. This classification can be implemented with just two periods of data. We also propose an alternative dynamic classification for businesses utilizing three periods of data. For the empirical portion of this paper, like many others, we adopt the basic approach of Foster, Haltiwanger and Krizan (2000/2001). We implement this decomposition using data for Taiwanese electronics firms. We first use the conventional dynamic status classification approach for firms and then use our suggested new FNN approach. We demonstrate the value of the FNN classifications.

Appendix A. The Total Factor Productivity Measure Utilized

The total factor productivity (TFP) is constructed using a multilateral index number approach developed by Caves, Christensen and Diewert (1982) and extended by Good, Nadiri and Sickles (1997). It was used in empirical studies such as Aw, Chen and Roberts (2001) and Fung (2008). The formula can be specified as:

$$\begin{aligned}\ln TFP_{it} &= (\ln Y_{it} - \overline{\ln Y_t}) + \sum_{\tau=1}^{t}(\overline{\ln Y_\tau} - \overline{\ln Y_{\tau-1}}) - \sum_j (1/2)(\delta_{ijt} + \overline{\delta_{jt}})(\ln x_{ijt} - \overline{\ln x_{jt}}) \\ &- \sum_{\tau=1}^{t}\sum_j (1/2)(\overline{\delta_{j\tau}} + \overline{\delta_{j\tau-1}})(\overline{\ln x_{j\tau}} - \overline{\ln x_{j\tau-1}}), \quad j = L, K, M, E, \end{aligned} \qquad \text{(A-1)}$$

where *i* indexes businesses and *j* inputs. Y_{it} is the output of a firm which is measured by three alternative methods that will be discussed below. x_{ijt} denotes input *j* in production, the inputs are: labor (L), capital (K), materials (M) and energy (E). Input shares (δ_{ijt}) are the shares of the firm's total expenditure attributable to input *j*. Assume perfect competition and constant returns to scale, a firm's input shares should sum up to one; therefore, the share of capital can be calculated as the residual share. $\overline{\ln Y}$, $\overline{\ln x_j}$, $\overline{\delta_j}$ denote the average of the logarithms of output and input, and input shares. Using this method, both the output and the input are expressed as a deviation from the mean in the base year (1986 in this paper). Conceptually, the output and input of a firm are compared to a fictitious firm (with output and input at the means) in the base year. This TFP measure captures both the difference between firm *i* and the fictitious firm in year *t* and the movements of means over the years.

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