

○ **FEATURE  
ARTICLE**





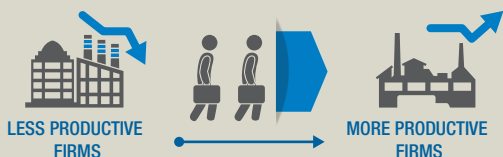
# FEATURE ARTICLE

# FIRM DYNAMICS AND THEIR IMPACT ON PRODUCTIVITY GROWTH IN THE MANUFACTURING SECTOR

## INTRODUCTION

In a well-functioning economy, market share and resources are likely to shift towards more productive firms as a consequence of competition. The shift can occur either through a **positive reallocation effect** or **positive churn effect**

### POSITIVE REALLOCATION EFFECT



Reallocation of labour from less productive to more productive firms among incumbent firms

### POSITIVE FIRM CHURN EFFECT

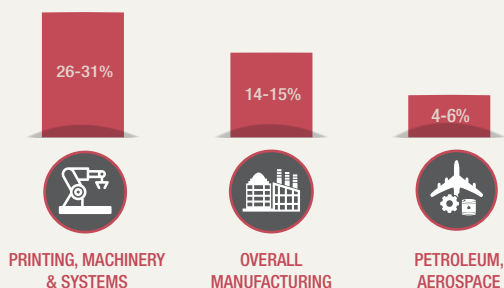


Exit of less productive firms and entry of more productive firms

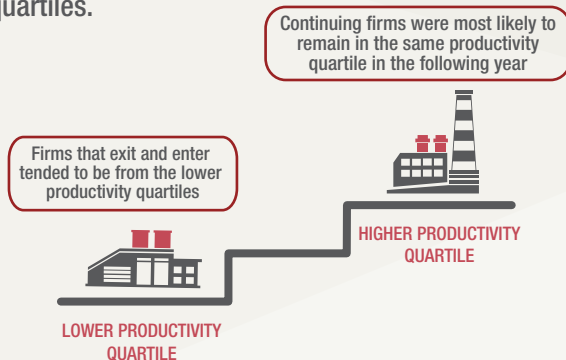
## FINDINGS

**Finding 1:** Firm churn was higher in segments such as printing and machinery & systems, likely due to a higher number of SMEs in these segments. Segments such as petroleum and aerospace, had lower entry and exit rates

### AVERAGE ENTRY AND EXIT RATES

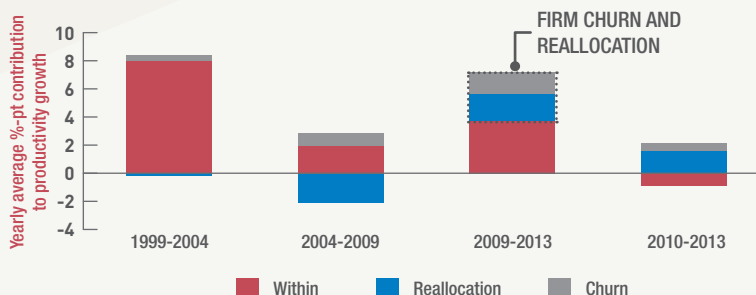


**Findings 2 & 3:** There was persistence in productivity, as continuing firms were most likely to remain in the same productivity quartile. Firms in the lower productivity quartiles were more likely to exit, while entry firms tended to start in the lower productivity quartiles.



**Finding 4:** Firm churn and reallocation effects contributed positively to productivity growth in the manufacturing sector over the 2009-2013 period

### DECOMPOSITION OF PRODUCTIVITY GROWTH IN THE MANUFACTURING SECTOR



## EXECUTIVE SUMMARY

- This article examines firm dynamics, especially the entry and exit of firms and the reallocation of labour across continuing firms, and their impact on productivity growth in the manufacturing sector. In terms of firm dynamics, our key observations are as follows: (i) different manufacturing segments had different rates of firm churn (i.e., the sum of exit and entry rates), with firm churn being higher in segments with a higher proportion of small- and medium-sized enterprises; (ii) there was persistence in the productivity performance of continuing firms; and (iii) firms in the lower productivity quartiles were more likely to exit, although entry firms also tended to start in the lower productivity quartiles.
- Next, we decompose labour productivity growth in the manufacturing sector into the contribution from (i) productivity improvements among continuing firms (i.e., within effect); (ii) the reallocation of labour across continuing firms of varying productivity levels and growth (i.e., reallocation effect); and (iii) the entry and exit of firms with different productivity levels (i.e., churn effect).
- Our results show that the firm churn effect contributed positively to productivity growth in the manufacturing sector for all three periods under study (i.e., 1999-2004, 2004-2009 and 2009-2013). In other words, firms entering the sector were more productive than firms exiting the sector on average in all time periods. There was also a net reallocation of labour from less productive firms to more productive firms in the sector in the latest period of 2009-2013. Collectively, the role of firm churn and reallocation effects in improving productivity was found to be significant after the Global Financial Crisis, accounting for 48 per cent of the improvement in productivity in the sector between 2009 and 2013.
- Our findings thus suggest that positive firm churn (where less productive firms exit and more productive firms enter) and the net reallocation of labour to more productive firms are important channels to achieve higher productivity growth in the Singapore economy.

*The views expressed in this paper are solely those of the authors and do not necessarily reflect those of the Ministry of Trade and Industry or the Government of Singapore.<sup>1</sup>*

## INTRODUCTION

In a well-functioning economy, market share and resources are likely to shift towards more productive firms as a consequence of competition. For instance, more productive firms are more likely to out-compete their less productive counterparts for customers, as well as to pay higher wages to attract workers. The shift in resources can thus occur either through a reallocation of labour from less productive to more productive firms among incumbent firms (i.e., positive reallocation effect) or through the exit of less productive firms and entry of more productive firms (i.e., positive churn effect). As the Singapore economy continues to restructure towards productivity-driven growth, both the firm churn and reallocation effects are likely to be important channels through which higher productivity growth can be achieved.

This study examines firm dynamics, particularly the entry and exit of firms and the reallocation of labour across continuing firms, in the manufacturing sector. It also quantifies the contribution of firm churn and the reallocation of labour across continuing firms to productivity growth in the sector.

## LITERATURE REVIEW

Many studies have explored the determinants of firm-level productivity and the extent to which productivity performance persists at the firm level. For example, Syverson (2011) reviews the determinants of firm-level productivity and finds that managerial practices, the skills of labour inputs and the quality of capital inputs (e.g., level of technology) are important drivers of productivity. Foster, Haltiwanger and Krizan (2006) further show that productivity performance tend to persist among incumbent firms in the US, with more productive firms generally remaining more productive over time and vice versa.

<sup>1</sup> We would like to thank Ms Yong Yik Wei for her useful suggestions and comments. We are also grateful to Ms Stephanie Mak for her inputs to this study. All remaining errors belong to the authors.

Several studies have also found that firm churn and the reallocation of labour across firms are important channels to improve productivity at the aggregate level. For the US economy, Baily, Hulten and Campbell (1992) show that firm churn and reallocation played a positive role in driving productivity growth in the manufacturing sector from 1977 to 1982, although the impact of reallocation was larger than that of firm churn. In a recent study, Foster, Grim and Haltiwanger (2016) show that while the reallocation of labour and firm churn continued to improve productivity in the US, their impact was far more limited during the Global Financial Crisis as compared to previous recessions.

Cross-country analyses were also carried out by Bartelsman, Haltiwanger and Scarpetta (2009) using data from the 1970s to the early 2000s. They find that the effect of firm churn was large and important in driving productivity growth across countries, while the effect of the reallocation of labour across firms varied significantly across countries.

## DATA

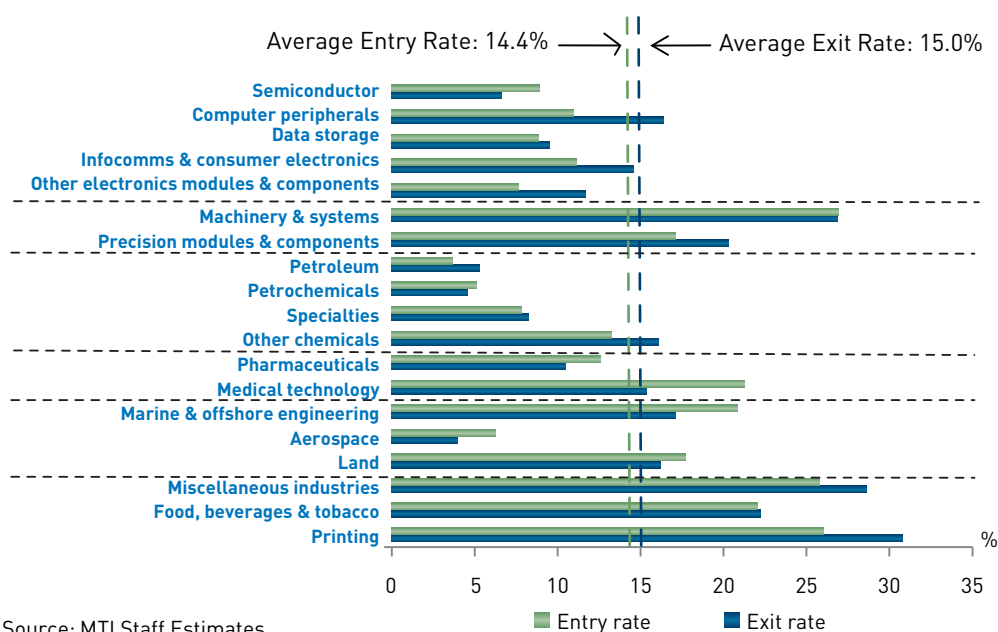
Our study uses anonymised firm-level data from the Census of Manufacturing Activities (CMA) survey for the years 1999 to 2013. The panel dataset tracks the performance of firms on an annual basis<sup>2</sup>, and contains firm-level characteristics such as the value-added and capital expenditure of the firm, the number of workers hired by the firm, and the manufacturing segment that the firm is in.

## TRENDS IN FIRM DYNAMICS AND PRODUCTIVITY

An examination of the data leads to three key observations on firm dynamics in Singapore's manufacturing sector over the period of 1999 to 2013.

First, different manufacturing segments had different rates of firm churn (i.e., the sum of exit and entry rates). Across the manufacturing segments, the average annual entry and exit rates<sup>3</sup> of firms were around 14 per cent and 15 per cent respectively (Exhibit 1). Firm churn tended to be higher in segments like the printing and machinery & systems segments, possibly due to a larger number of small- and medium-sized enterprises (SMEs) in these segments. By contrast, segments generally dominated by larger firms, such as the petroleum and aerospace segments, had lower entry and exit rates of around 4 per cent to 6 per cent.

**Exhibit 1: Average entry and exit rates for each segment over the 1999 to 2013 period**



<sup>2</sup> The CMA survey covers with certainty larger firms with more than 20 workers, and once surveyed, will be surveyed in subsequent years unless the company's employment falls below 20. For firms with less than 20 workers, they will be randomly sampled.

<sup>3</sup> Exit rate is calculated as the number of firms out of the total number of firms in a particular year that had exited by the following year. Entry rate is calculated as the number of firms that had entered in a particular year out of the total number of firms in that year.

Second, there was persistence in the productivity ranking of continuing firms. Firms were first grouped into productivity quartiles based on their productivity performance in a particular year. The transition matrix in Exhibit 2 tracks the productivity quartile where the firms in each quartile ended up in the following year. For example, 70 per cent of the firms in the highest productivity quartile (i.e., 4<sup>th</sup> quartile) in the initial year remained in the highest productivity quartile the next year. From the transition matrix, it is clear that the most likely outcome for firms in each productivity quartile is that they will remain in the same quartile the following year.

Third, firms in the lower productivity quartiles were more likely to exit, while entry firms also tended to start in the lower productivity quartiles (Exhibit 2). Specifically, firms in the 1<sup>st</sup> productivity quartile had a 25 per cent probability of exiting the next year compared to a 9 per cent probability for firms in the 4<sup>th</sup> quartile. In terms of entry firms, 39 per cent of them started in the 1<sup>st</sup> productivity quartile, while only 18 per cent started in the 4<sup>th</sup> quartile.

**Exhibit 2: Transition matrix groups firms into productivity quartiles in the initial year and tracks their productivity quartile (or exit) in the next year**

		Next Year					Total
		1st Quartile	2nd Quartile	3rd Quartile	4th Quartile	Exit firms	
Initial Year	1 <sup>st</sup> Quartile	51%	17%	4%	3%	25%	100%
	2 <sup>nd</sup> Quartile	16%	47%	16%	3%	17%	100%
	3 <sup>rd</sup> Quartile	5%	19%	49%	16%	12%	100%
	4 <sup>th</sup> Quartile	2%	3%	16%	70%	9%	100%
	Entry firms	39%	24%	20%	18%	-	100%

Source: MTI Staff Estimates

Note: The 1<sup>st</sup> quartile is the least productive and 4<sup>th</sup> quartile is the most productive. Transitions matrices were calculated annually from 1999-2013 for 19 manufacturing segments. Reported in the matrix above are the average percentages for all years and all segments.

## DECOMPOSITION METHODOLOGY

Next, we quantify the contribution of firm churn and reallocation effects to productivity growth in the manufacturing sector.

Previous studies such as Goh (2014) and Goh and Fan (2015) had focused on the decomposition of Singapore's aggregate labour productivity growth into the contribution of within and shift effects at the *industry* level. The studies showed that within-industry productivity improvements contributed positively to aggregate labour productivity growth, whereas the shift effect across industries had been negative in recent years as less productive industries (e.g., construction) saw an increase in employment share.

In our study, we adopt a similar shift-share approach, but analyse the contribution of changes in labour productivity, reallocation and churn effects at the *firm*-level to manufacturing labour productivity. Specifically, we adopt the decomposition framework from Foster, Haltiwanger and Krizan (2001) to decompose labour productivity growth for each manufacturing segment into the following components:

- Within-firm productivity improvements: This is the contribution of each continuing firm's productivity growth to its segment's productivity growth.
- Reallocation of workers across continuing firms: This is the contribution from relative employment shifts into firms with different productivity levels (the "between" effect) or different productivity growth rates (the "cross" effect). Reallocation contributes positively to productivity growth when firms with higher productivity levels or faster productivity growth rates gain employment shares.

- Churn due to entry and exit of firms: This is the contribution of entering and exiting firms to the segment's productivity growth. Firm churn's contribution is positive when, on net, firms entering the segment are more productive than the firms exiting.

In equation form, the decomposition framework can be represented as:

$$\frac{\Delta P_{it}}{P_{it-1}} = \frac{\sum_{e \in C} s_{et-1} \Delta P_{et}}{P_{it-1}} \quad \text{Within}$$

$$+ \frac{\sum_{e \in C} (P_{et-1} - P_{it-1}) \Delta s_{et}}{P_{it-1}} \quad \text{Between}$$

$$+ \frac{\sum_{e \in C} \Delta s_{et} \Delta P_{et}}{P_{it-1}} \quad \text{Cross}$$

$$+ \frac{\sum_{e \in N} s_{et} (P_{et} - P_{it-1})}{P_{it-1}} \quad \text{Entry}$$

$$- \frac{\sum_{e \in X} s_{et-1} (P_{et-1} - P_{it-1})}{P_{it-1}} \quad \text{Exit}$$

} Reallocation

} Churn

Where  $P_{it}$  is the nominal labour productivity of firm  $e$  in segment  $i$  in year  $t$ ;  
 $s$  denotes the firm's labour share within the segment;  
 $C$ ,  $N$  and  $X$  denote continuing, entering and exiting firms respectively.

We apply the decomposition framework on 19 manufacturing segments<sup>4</sup>, and then average the results over all the segments to obtain the results for the manufacturing sector as a whole.<sup>5</sup> Our decomposition analysis was carried out for three time periods: 1999-2004, 2004-2009 and 2009-2013.

## RESULTS OF DECOMPOSITION ANALYSIS

Using the decomposition methodology outlined above, we find that the firm churn effect contributed positively to productivity growth in the manufacturing sector for all three time periods under study, while the reallocation effect contributed positively in the most recent period of 2009-2013 (Exhibit 3).

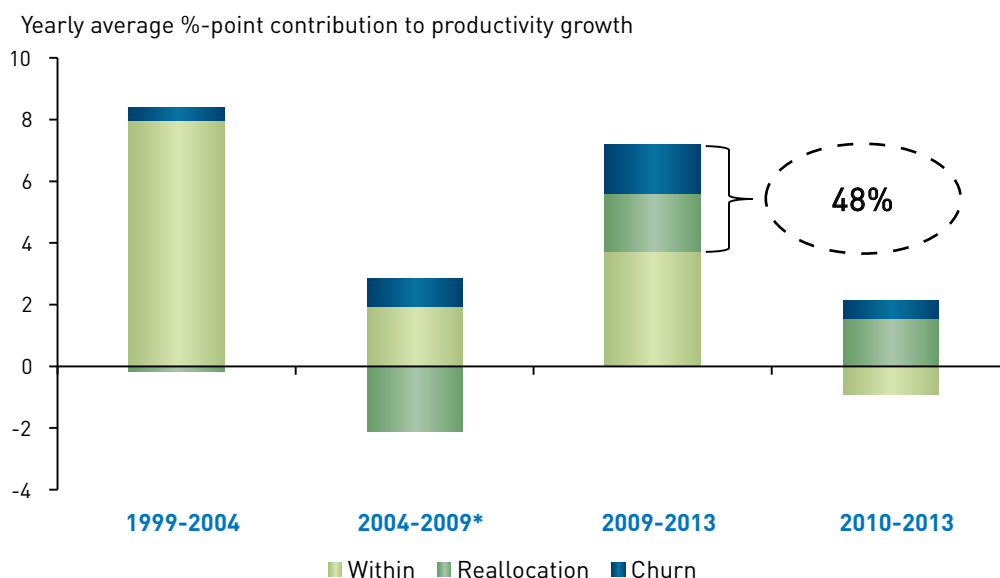
Collectively, the role of firm churn and reallocation effects in improving productivity became more significant after the Global Financial Crisis (GFC) (i.e., 2009-2013 period), accounting for 48 per cent of the overall improvement in productivity during this period. This was primarily due to a larger positive churn effect, with its contribution to productivity growth rising from 0.4 percentage-points (pp) during the 2004-2009 period to 1.6pp in the post-GFC period. The reallocation effect also contributed to improvements in productivity in the post-GFC period. The tightening of manpower policies in recent years would have tilted the balance towards more productive firms with higher capital intensity, as these firms are likely to be able to offer higher wages and hence increase their employment shares.

<sup>4</sup> The 19 manufacturing segments are semiconductor, computer peripherals, data storage, infocommunications & consumer electronics, other electronic modules & components, petroleum, petrochemicals, specialty chemicals, other chemicals, pharmaceuticals, medical technology, machinery & systems, precision modules & components, marine & offshore engineering, aerospace, land transport, food, beverages & tobacco, printing and miscellaneous industries.

<sup>5</sup> The results are robust whether we take a simple average or weighted averages.

At the same time, the within effect (i.e., productivity growth at the firm level) was positive and sizable in the post-GFC period, contributing 3.7pp to overall productivity growth during this period. This was largely due to a sharp rebound in firms' productivity performance in 2010 as the economy recovered from the GFC. Excluding 2009-2010, the within effect exerted a negative drag on productivity over the 2010-2013 period. The negative within effect for this period could be due to cyclical headwinds faced by manufacturing firms against the backdrop of a sluggish global economic environment.

**Exhibit 3: Decomposition results for each time period**



Source: MTI Staff Estimates

\*Note: The within effect for the petrochemicals segment was excluded as this segment experienced a surge in this effect during the period.

## CONCLUSION

This study analyses firm dynamics in the manufacturing sector. Our key observations are as follows. First, different manufacturing segments had different rates of firm churn. Segments which had a greater share of SMEs tended to experience more churn. Second, there is persistence in firm-level productivity rankings from year to year. Third, firms in the lower productivity quartiles were more likely to exit, although entry firms also tended to start in the lower productivity quartiles.

Based on a decomposition analysis using firm-level data, we find that both the firm churn and reallocation effects contributed positively to productivity growth in the manufacturing sector over the 2009-2013 period, accounting for 48 per cent of the sector's productivity growth during this period. This suggests that our restructuring efforts have by and large been effective in helping more productive firms in the manufacturing sector to grow, even as other firms consolidate or shift to other business areas.

As the Singapore economy continues to restructure to achieve productivity-driven growth, such channels of productivity improvements will remain important. Government policies should hence continue to encourage firms to innovate and adapt, even while allowing competitive market forces to work. To further improve our understanding of firm dynamics and their impact on productivity in the Singapore economy, future studies could extend the current analysis to the services and construction sectors.



*Contributed by:*

Gwee Yi Jie, Economist  
Lee Zen Wea, Economist  
Vera Lim, Economist  
Dr Andy Feng, Senior Economist  
Economics Division  
Ministry of Trade and Industry

## REFERENCES

Baily, Martin Neil, Charles Hulten, and David Campbell. 1992. "Productivity Dynamics in Manufacturing Plants." In *Brookings Papers on Economic Activity: Microeconomics*, ed. Clifford Winston and Martin Neil Baily. Washington, DC: Brookings Institution Press.

Bartelsman, Eric, John Haltiwanger, and Stefano Scarpetta. 2009. "Measuring and Analyzing Cross-country Differences in Firm Dynamics." In *Producer Dynamics: New Evidence from Micro Data*, ed. Timothy Dunne, J. Bradford Jensen, and Mark J. Roberts. Chicago and London: University of Chicago Press.

Foster, Lucia, Cheryl Grim, and John Haltiwanger. 2016. "Reallocation in the Great Recession: Cleansing or Not?" *Journal of Labor Economics* 34(S1, Part 2, January 2016): S293-S331.

Foster, Lucia, John Haltiwanger, and C.J. Krizan. 2006. "Market Selection, Reallocation and Restructuring in the U.S. Retail Trade Sector in the 1990s." *Review of Economics and Statistics* 88(4): 748-58.

Foster, Lucia, John Haltiwanger, and C.J. Krizan. 2001. "Aggregate Productivity Growth: Lessons from Microeconomic Evidence." In *New Developments in Productivity Analysis*, ed. Charles R. Hulten, Edward R. Dean, and Michael J. Harper. Chicago and London: University of Chicago Press.

Goh, Tee Wei. 2014. "Feature Article: A Shift-Share Analysis of Singapore's Labour Productivity Growth, 1998-2013." *Economic Survey of Singapore* 2013: 70-77.

Goh, Tee Wei and Fan Shir Li. 2014. "Feature Article: Drivers of Labour Productivity Growth Trends in Singapore." *Economic Survey of Singapore* 2014: 76-87.

Syverson, Chad. 2011. "What Determines Productivity?" *Journal of Economic Literature* 49(2): 326-365.