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Exporter Dynamics and Productivity Dispersion within Industry*

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Abstract: *This paper uses firm-level panel data for Japan to examine between-firm productivity dispersion, and explore whether export market entry improves productivity and accelerates productivity catch-up by new exporters in relation to frontier firms. Even though a sizable number of firms start exporting every year, this paper's results show that, on average, these new exporters' productivity growth rates tends to deteriorate after export market entry. The results also imply that in the case of Japan the sluggish productivity growth experienced by almost all firms may be attributable to the very low or even negative productivity growth of national frontier firms or top exporters.*

***Keywords*:** Firm-level data; Export; Productivity.

***JEL Classification*:** L15; O47; F14; F43

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1. Introduction

The existence of a significant and persistent productivity gap between high-performing firms and low-performing firms has been confirmed by many studies (e.g. Andrews et al. 2016; Berlingieri et al. 2017). This increasing and persistent productivity gap between firms has been becoming an important issue for both academics and policymakers because it also seems to be associated with the growing income gap across workers (e.g. Helpman et al., 2017).

Previous studies have argued that globalisation and technological changes might be associated with increased between-firm productivity dispersion.[1] Although productivity dispersion can be explained by different rates of technology adaption and/or technology diffusion across firms, worldwide trade liberalisation is also likely to increase between-firm productivity dispersion.[2] In many countries, exporters tend to exhibit higher productivity than non-exporters. There are two potential effects that explain the productivity gap between exporters and non-exporters, i.e. the selection effect whereby only productive firms serve the international market, and the learning-by-exporting effect whereby internationalised firms becoming more productive. If these two potential effects reinforce each other, the productivity gap between firms that are actively engaged in international business and the remaining, i.e. non-internationalised, firms will increase. Moreover, exporters are more likely to be importers, and they tend to increase offshoring of non-core activities while concentrate on high-value-added, high-pay activities at home, resulting in the higher performance of internationalised firms.

In fact, many previous studies have confirmed that only limited number of firms can be exporters, and even amongst exporters, the top 1%, i.e. the 'largest of the large' firms, account for the majority of a country's exports (e.g. Mayer and Ottaviano 2008).[3]

[1] Other possible reasons for productivity dispersion would be the market environment and institutional changes, amongst others.

[2] Ito and Lechevalier (2009) found evidence of a significant and positive impact of internationalization on productivity dispersion in the case of Japan.

[3] Many studies such as those by Bernard et al. (2016) and Freund and Pierola (2015) also documented the concentration of exporting in a few largest firms. Freund and Pierola (2015) called them 'export superstars' and found that very large firms shape a country's export patterns.

Much international trade is dominated by a few 'global firms' that participate in the international economy along multiple margins. Bernard et al. (2016) pointed out that more successful firms export more of each product to each country, export more products to each market, export to more markets, import more of each product from each source country, import more products from each source country, and import from more source countries. Bernard et al. (2016) argued that global firms have superior performance because small differences in exogenous firm characteristics are magnified by these endogenous market participation decisions, increasing the global firms' shares of aggregate trade.

However, if knowledge spillovers mostly emanate from frontier technology and if laggard firms learn from frontier firms, the laggards may in fact use that knowledge to improve performance and close the gap with the productivity frontier firms. In such a case, the productivity gap will not continue to increase by substantial amounts. As Bartelsman et al. (2008) argued, the process of productivity growth and convergence can be illustrated by frontier growth, and the catch-up by the laggards. Moreover, in the globalised economy, global frontier technology may likely diffuse not only to national frontier firms but also to domestic laggard firms: National frontier firms are likely to have access to the global market and learn from global frontier firms, whereas the laggard firms are likely to learn global frontier technology via the national frontier firms. The existence of such a convergence process implies that globalisation is likely to raise the overall productivity level of an economy even though the productivity gap between internationalised and non-internationalised firms does not shrink by a substantial amount.

In the case of Japan, as shown later in this paper, a large and persistent productivity gap exists between national frontier firms (highest-ranking firms in terms of productivity or export volume distribution) and other firms. More importantly, productivity has been stagnant, with a lack of growth experienced by both frontier and laggard firms during the period analysed in this study, i.e. from 1997 to 2013. On the other hand, reflecting worldwide trade liberalisation and low domestic demand growth, the number of exporters has been increasing. These observed facts may imply that the productivity convergence process toward the global frontier does not work well in the case of Japan, although the reason for this is not clear.

This paper uses firm-level panel data for Japan to examine between-firm productivity dispersion and explore whether export market entry improves productivity and accelerates productivity catch-up by new exporters in relation to frontier firms. I also examine the importance of the pull from frontier firms for catch-up by laggard firms and investigate the role of new exporters and incumbent large exporters in increasing/decreasing productivity dispersion and overall productivity growth.

The following sections (1) examine between-firm productivity gap and export market participation in the case of Japan for the period from 1997 to 2013, (2) investigate whether one can observe the convergence process where productivity frontier firms grow and laggard firms catch up toward the frontier, and (3) examine whether export market entry accelerates productivity catch-up by new exporters toward the frontier.

The rest of the paper is organised as follows. Section 2 provides a brief literature review. Section 3 describes the data and presents descriptive analyses on differences in productivity and export status between frontier and other firms. Section 4 examines productivity growth and the catch-up of laggard firms to frontier firms, focusing on the effect of changes in a firm's export status. Section 5 further investigates frontier productivity and technological capabilities. Section 6 summarises the results and highlights the key policy implications.

2. Literature Review

Current research in international trade centres on the importance of both the intensive margin (i.e. volume exported by an exporter) and extensive margin (i.e. new exporters) to model export behaviour. Studies such as those by Helpman et al. (2008), Besedes and Prusa (2011), and Bernard et al. (2007), suggest that changes in aggregate trade volume are heavily influenced by extensive margin adjustments (new export destinations, new export products, or new exporters) rather than intensive margin adjustments (export volume changes for existing export destination, existing export products, and existing exporters). However, examining the firm-level exports, aggregate

exports are highly concentrated amongst a very small set of firms that are the most productive and participate in the international economy along multiple margins (Berthou et al., 2015; Bernard et al., 2016; De Lucio et al., 2017; etc.).

Moreover, as Besedes and Prusa (2011), Békés and Muraközy (2012), Inui et al. (2017), and others have noted, most export relationships are very short-lived. These studies suggest that becoming permanent exporters is not easy and that new exporters require time to learn from exporting and improve their productivity. As a result, we can observe a substantial difference in firm size, productivity, export volume, and so on, between new exporters and the top exporters such as the highest or top 10 ranking firms, or the top 1% of exporters (Berthou et al., 2015; Freund and Pierola, 2015; etc.)

On the other hand, Andrews et al. (2016) observed that the productivity gap between global productivity frontier firms and laggard firms has been increasing and that the pace of laggard firms' catch-up to the global productivity frontier has declined noticeably. Although the reasons behind the declining pace of laggard firms' catch-up have not yet been sufficiently investigated, small differences in firm productivity would have magnified consequences for the performance of global frontier firms that participate intensively in the world economy along multiple margins, as suggested by Bernard et al. (2016). Global frontier firms lower their production costs by sourcing inputs from more countries and expand their scale of operation by exporting more products to each market and/or exporting to more markets.

In fact, in many countries, the productivity premium of exporters vis-à-vis non-exporters is rising along with the firms' export experience, with permanent exporters being much more productive than starters (e.g. Berthou et al., 2015). Berthou et al. (2015) also showed that top exporters are far more productive than other permanent exporters.

On the other hand, as mentioned in the Introduction, if the catch-up process suggested by Bartelsman et al. (2008) does in fact function as anticipated, both globalised frontier firms and non-globalised laggard firms may grow even though the productivity gap between these two types of firms does not shrink by a great amount. Bartelsman et al. (2008) and other related studies such as those by Van der Wiel et al. (2008), Iacovone and Crespi (2010), and Andrews et al. (2015) discovered evidence of convergence toward both the national and global frontiers, although the pull of the

national frontier is stronger than that of the global frontier. These results suggest a convergence process, wherein more technologically advanced firms tend to catch up toward the global frontier while relatively more laggard firms are still able to learn from the national frontier. Moreover, Iacovone, and Crespi (2010) found that openness of trade facilitates convergence toward the national frontier, although they also emphasise the importance of absorptive capacity development in enabling catch-up toward the global frontier.

Thus, these studies suggest that although globalisation underpinned by trade liberalisation may have increased the productivity gap between frontier firms and non-frontier firms, globalisation may also accelerate convergence toward the national and the global frontiers. If the frontier firms grow as a result of benefiting from the global market while non-frontier firms catch up toward the frontier, we expect both frontier and non-frontier firms to grow even though the productivity gap between them does not show much reduction. If this process is accurate, then top exporters, who are very likely to be productivity frontier firms, should play an important role in aggregate productivity growth even though extensive margin adjustments by entry to and exit from export markets would be important for export growth.

A large body of literature has studied exporter dynamics such as entry, exit, and survival in export markets, as well as exporter productivity evolution such as learning by exporting. However, studies that associate exporter dynamics with between-firm productivity dispersion within the industrial sector are very scarce. Regarding Japanese firms, Ito and Lechevalier (2009) found that the increasing productivity dispersion within an industry is positively associated with that industry's trade openness (import and export intensities). However, they do not analyse exporter dynamics or aggregate productivity growth.

3. Between-Firm Productivity Dispersion

3.1. Description of data

The main dataset used in this study contains firm-level panel data obtained from the Basic Survey of Japanese Business Structure and Activities (BSJBSA), which is

collected annually by Ministry of Economy, Trade and Industry (METI) for the period 1997–2013.[4] The survey is compulsory and covers all firms with at least 50 employees or 30 million yen of paid-in capital in the Japanese manufacturing, mining, wholesale and retail sectors, and several other service sectors. The survey contained detailed information on firm-level business activities such as the 3-digit industry in which the firm operates, and the number of employees, sales, purchases, exports, and imports. It also contained the number of domestic and overseas subsidiaries, amount of research and development (R&D) expenditure, and various other financial data such as costs, profits, investment, debts, and assets.

Using the firm-level panel data underlying the BSJBSA, I conducted detailed analyses on the evolution of productivity at the firm level as well as the process of productivity dispersion across firms within industry. I also identified export starters, stoppers, permanent exporters, top exporters, and non-exporters using the firm-level panel data, and examine the contributions of each type of exporter to aggregate export growth.

The unbalanced panel data contained approximately 11,000 manufacturing firms, 7,000 wholesale and retail trade firms, and 6,000 services firms per year. Although international transactions are becoming increasingly important for service firms, I mainly focused on manufacturing firms in this paper because the number of firms reporting service trade is very limited, and therefore it is difficult to conduct rigorous statistical analysis on non-manufacturing firms. The number of firms in the dataset is summarised in Table 1.[5]

Using the firm-level panel data from 1997 to 2013, I calculated the firm-level Total Factor Productivity (TFP) based on the technique developed by Wooldridge (2009), which in turn builds on the method of Levinsohn and Petrin (2003) but also overcomes the identification problem. It is a quicker one-step procedure that obtains consistent standard errors without bootstrapping. The value-added-based Wooldridge TFP measure is mainly used in this paper. The approach was chosen because more severe

[4] Although firm-level panel data are available from 1994, the definitions of exports and imports in the data before 1997 are different from those used from 1997 onwards. Therefore, in this paper, I mainly used the firm-level panel data from 1997 to 2013.

[5] The number of firms by industry is summarised in Appendix Table 1.

identification issues arise when using gross output as the dependent variable of the production function estimation to derive TFP (see Bond and Söderbom 2005).[6] In addition, I measured firm-level markup based on the technique developed by De Loecker and Warzynski (2012). In this paper, I mainly examined the following two measures: (1) log TFP (markup not corrected, so-called revenue TFP) and (2) log TFP (markup corrected).

Table 1. Number of Firms

Year	All industries			Manufacturing		
	Total	Goods exporters	(%)	Total	Goods exporters	(%)
1997	21,558	4,406	(20.4)	11,052	2,814	(25.5)
1998	21,523	4,428	(20.6)	11,081	2,844	(25.7)
1999	21,170	4,519	(21.3)	10,936	2,934	(26.8)
2000	22,556	4,653	(20.6)	10,720	3,013	(28.1)
2001	22,970	4,786	(20.8)	10,673	3,091	(29.0)
2002	22,446	4,836	(21.5)	10,393	3,103	(29.9)
2003	21,731	4,719	(21.7)	10,037	3,074	(30.6)
2004	23,016	5,116	(22.2)	10,627	3,353	(31.6)
2005	22,562	5,110	(22.6)	10,437	3,364	(32.2)
2006	22,650	5,083	(22.4)	10,321	3,347	(32.4)
2007	23,531	5,275	(22.4)	11,399	3,816	(33.5)
2008	23,900	5,319	(22.3)	11,519	3,849	(33.4)
2009	23,809	5,338	(22.4)	11,358	3,896	(34.3)
2010	24,398	5,543	(22.7)	11,480	4,013	(35.0)
2011	25,334	5,653	(22.3)	11,734	4,074	(34.7)
2012	29,142	6,511	(22.3)	13,223	4,647	(35.1)
2013	28,818	6,519	(22.6)	13,103	4,674	(35.7)
Total	401,114	87,814		190,093	59,906	

Source: Author.

As shown in Panel (a) of Figure 1, the productivity gap between firms in the top decile and those in the bottom decile of the TFP (markup not corrected) distribution in each year has been slightly widening in both the manufacturing sector and non-manufacturing sector. Although the production function is estimated by 2-digit industry level, for simplicity, Figure 1 shows the TFP distribution for all manufacturing

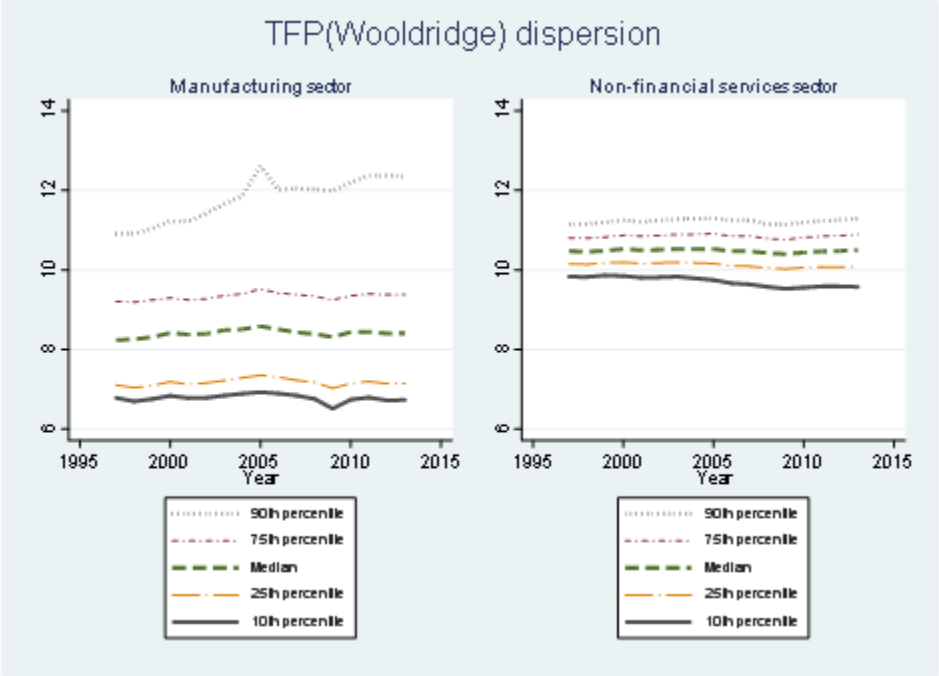
[6] The production function is estimated for each 2-digit industry for each country, and the firm-level TFP is calculated using the MultiProd Version 1.1.2 Stata routines developed by the OECD MultiProd team. The MultiProd project is based on a distributed data collection exercise aimed at creating a harmonised cross-country micro-aggregated database on productivity dynamics from confidential micro-level data where the primary sources of firm and establishment data are national business registers or censuses.

firms and all non-financial services firms. Therefore, it should be noted that the evolution of TFP dispersion in Figure 1 contains both changes to within-industry productivity dispersion and changes in industry compositions each year.

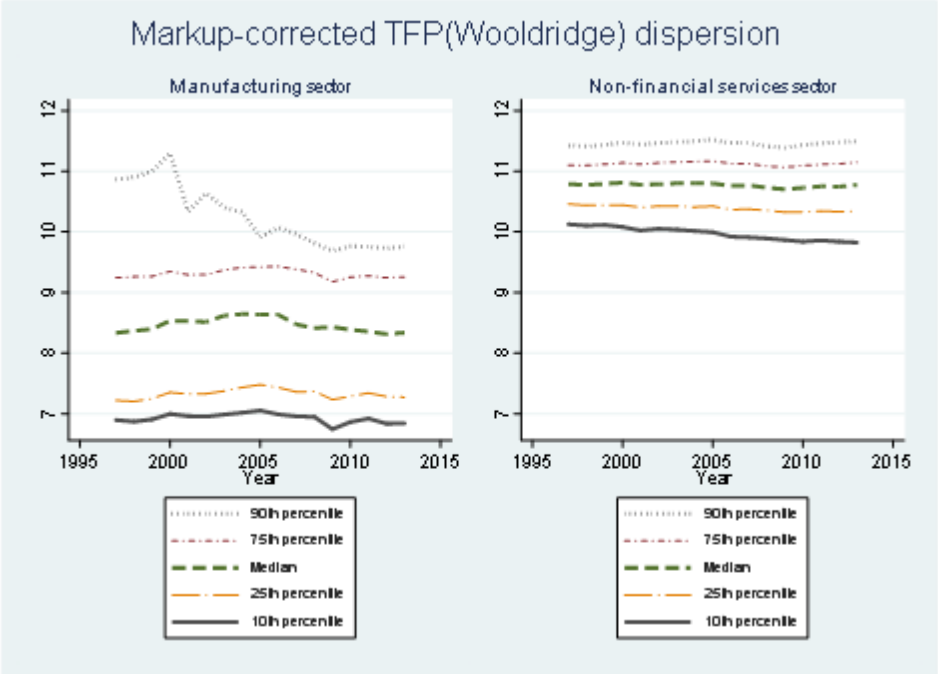
Panel (b) of Figure 1 also shows that a substantial productivity gap exists between firms, even based on markup-corrected TFP. However, in the case of the manufacturing sector, the top-decile markup-corrected TFP declined significantly, implying that a large part of the revenue TFP growth for top-decile firms shown in Panel (a) was driven by markup growth. Although the markup-corrected TFP dispersion has been decreasing in the manufacturing sector, it has been slightly increasing in the non-financial-services sector.

Thus, productivity dispersion has not clearly increased, particularly in the manufacturing sector; rather, it has been decreasing. However, dispersion is still large and persistent. More importantly, TFP growth for Japanese firms has been very low and stagnant. In particular, the bottom decile of TFP has been slightly declining. Although productivity dispersion per se may not be a problem, persistent dispersion combined with a low growth rate may reflect the fact that most Japanese firms, particularly firms far from the productivity frontier, do not close the gap with national/global frontier firms, and thus the productivity convergence process suggested by Bartelsman et al. (2008) does not work.

Figure 1. Trends of (log) TFP Distribution
Panel (a) TFP (markup not-corrected) Dispersion



Panel (b) TFP (markup corrected) Dispersion



TFP = Total Factor Productivity.
Source: Author.

3.2. Productivity and export status

To investigate possible reasons behind the persistence of the productivity gap, I considered the relationship between various firm characteristics and TFP levels. The descriptive analyses in this sub-section focused on manufacturing firms, though the overall situation is very similar when non-manufacturing firms are included. As mentioned in Section 1, firms' exposure to international markets may be one reason for the productivity gap, although it should not be only one reason. Therefore, in this paper, I focused on differences in firms' export status and examine whether and how much performance differs across firms depending on export status.[7]

Figure 2 shows export premia, which are calculated as log differences in firm size (sales), TFP, and markup of exporters and non-exporters in the same industry.[8] The log differences are calculated by 2-digit industry level, and the within-industry differences are converted to country level by taking the simple unweighted average over industries and years. Top exporters are determined by ranking firms' export volumes (nominal export values) for each 2-digit industry and each year. The top 10 exporters are the 10 largest exporters in terms of export values, and the top one percentile exporters are the exporters who are ranked at the top 1% of the export value distribution for each industry and each year. Industries with fewer than 10 exporters are excluded. Furthermore, in cases where there are fewer than 100 exporters in an industry in a year, the top 1% of exporters cannot be defined.[9] As shown in Figure 2, although exporters outperform non-exporters, a large dispersion can be observed amongst the population of exporters. For example, the top 10 exporters are conspicuously larger and more productive. In addition, they charge much higher markups. Although new exporters are more productive than non-exporters, they are remarkably less productive than the permanent exporters.

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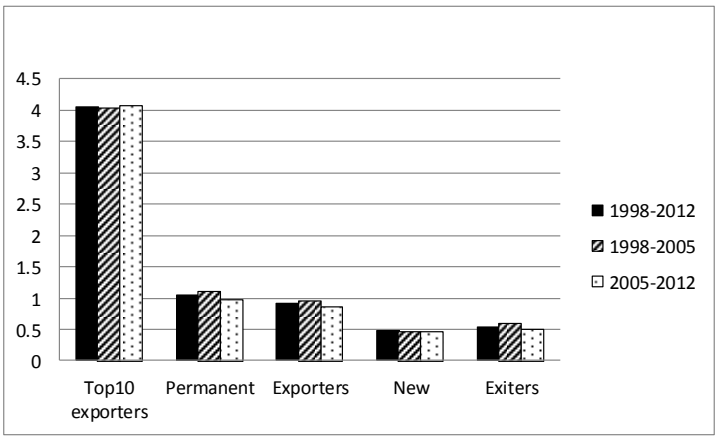
[7] Firms' export status is defined using the firm-level export data for three consecutive years. As shown in Appendix Table 2, I identify whether or not a firm exports in years $t-1$, t, and $t+1$, and define the firm's export status in year t.

[8] Figure 2 shows the average export premia for the three periods: the whole period from 1998 to 2013, the first half of the period from 1998 to 2005, and the second half of the period from 2005 to 2013. The year 2005 is the mid-year of the dataset used in this paper, and it also corresponds to the peak year of the Japanese firms' productivity on average prior to the 2008 global financial crisis.

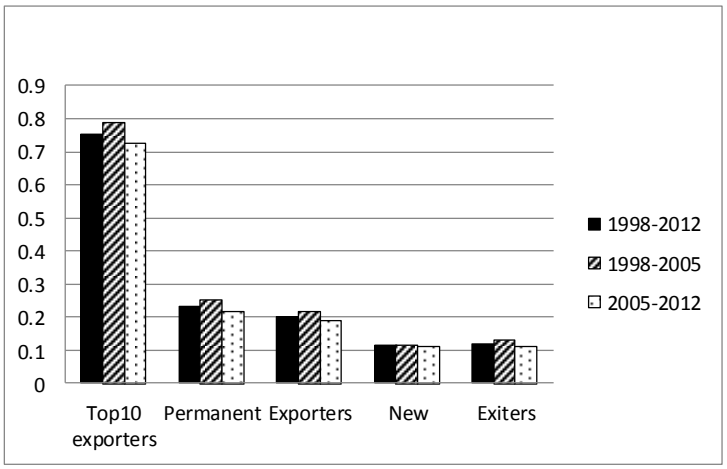
[9] We may take only the top exporter into account for such a case. However, in this study, I did not define the top 1 percentile of exporters for such a case.

Figure 2. Export Premia over Export Status: Manufacturing Sector

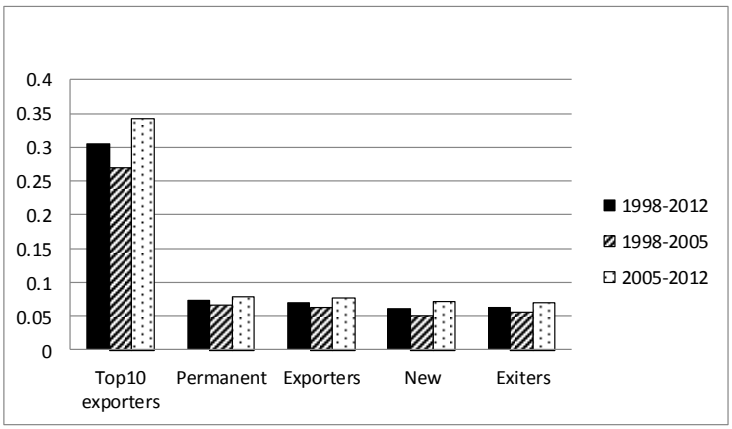
Panel (a) Export Premia in Sales



Panel (b) Export Premia in TFP (markup not-corrected)



Panel (c) Export Premia in Markups

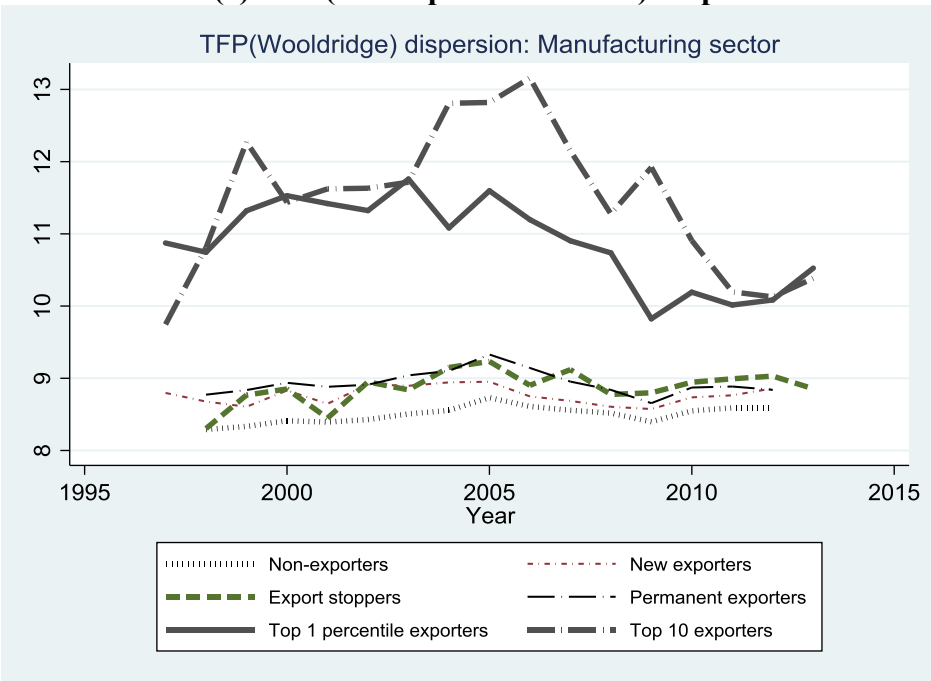


TFP = Total Factor Productivity.
Source: Author.

Figure 3 shows the evolution of average productivity by export status over time. Export status is defined by 2-digit industry level in the same way as in Figure 2, but Figure 3 presents the average productivity level for firms in each export status category. Although the productivity gap between top exporters and other firms has somewhat declined in the latter half of the period shown in Figure 3, this reduction is mainly attributable to the large productivity declines experienced by top exporters.[10] Although these large declines in top exporters' productivity is an important research question, we confirm in Figure 3 that a persistent productivity gap exists between firms and that productivity growth is sluggish for most firms regardless of their export status.

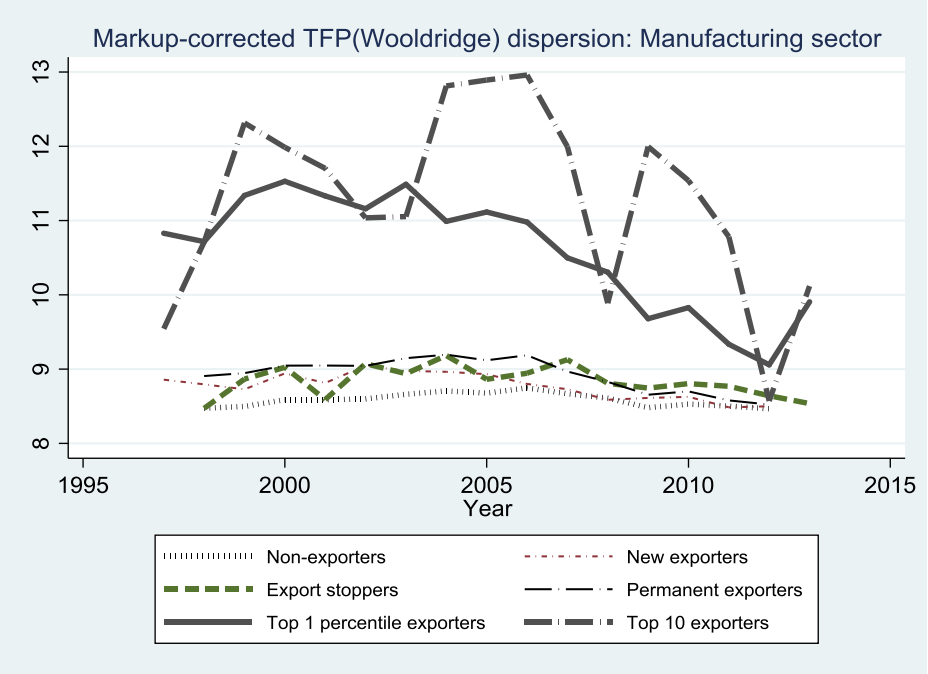
Figure 3. Productivity Differences across Firms by Export Status: Manufacturing Sector

Panel (a) TFP (markup not-corrected) Dispersion



[10] The large fluctuation in the top 10 exporters' productivity may partly due to the small sample size.

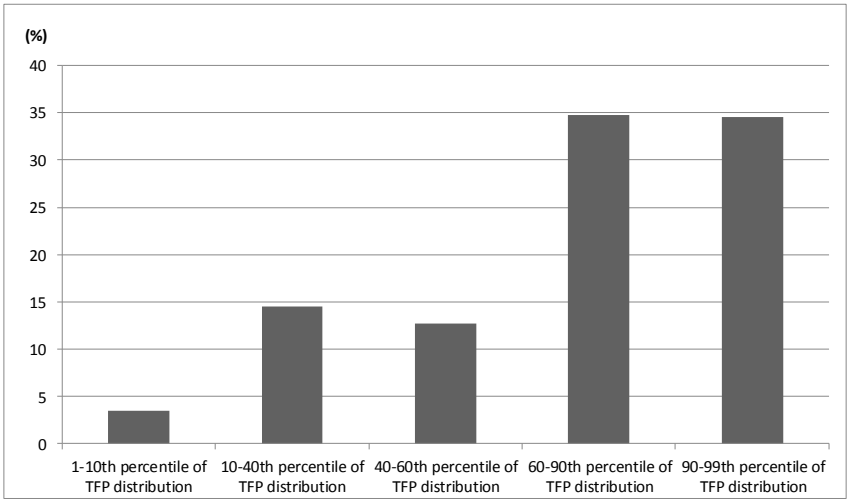
Panel (b) TFP (markup corrected) Dispersion



TFP = Total Factor Productivity.
Source: Author.

To relate the productivity gap between exporters and non-exporters to the productivity gap between high- and low-productivity firms, I examined where the top exporters fall along the productivity distribution. Figure 4 shows the productivity distribution of the top 10 exporters. For each industry and each year, I identified the top 10 exporters as explained previously and examined the location of these top exporters along the TFP distribution for each industry and each year. Figure 4 confirms that top exporters are concentrated in the top 40 percentiles of the TFP distribution, and that top exporters tend to be high-productivity firms in each industry. I also confirmed that high-productivity firms are more likely to be permanent exporters, whereas low-productivity firms are more likely to be non-exporters (Appendix Figure 1).

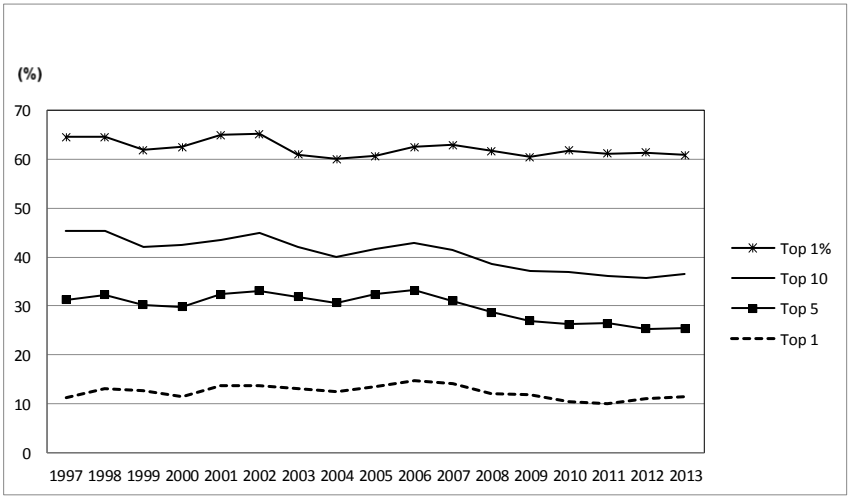
Figure 4. Distribution of Top 10 Exporters (manufacturing)



TFP = Total Factor Productivity.
Source: Author.

Top exporters also account for a substantial proportion of total exports. Figure 4 confirms that the top one percentile of exporters for each industry account for over 60% of total exports. Furthermore, the top exporter in each industry accounts for over 10% of that industry's total exports. Such a concentration of exports within top exporters is also observed by many previous studies on other countries (e.g. Mayer and Ottaviano 2008, Bernard et al. 2009, and Freund and Pierola 2015).[11]

Figure 5. Share of Top Exporters in Total Goods Exports (manufacturing)



Source: Author.

[11] I also confirmed that high-productivity firms tend to conduct more international activities: exports, imports, and outward FDI (Appendix Figure 2).

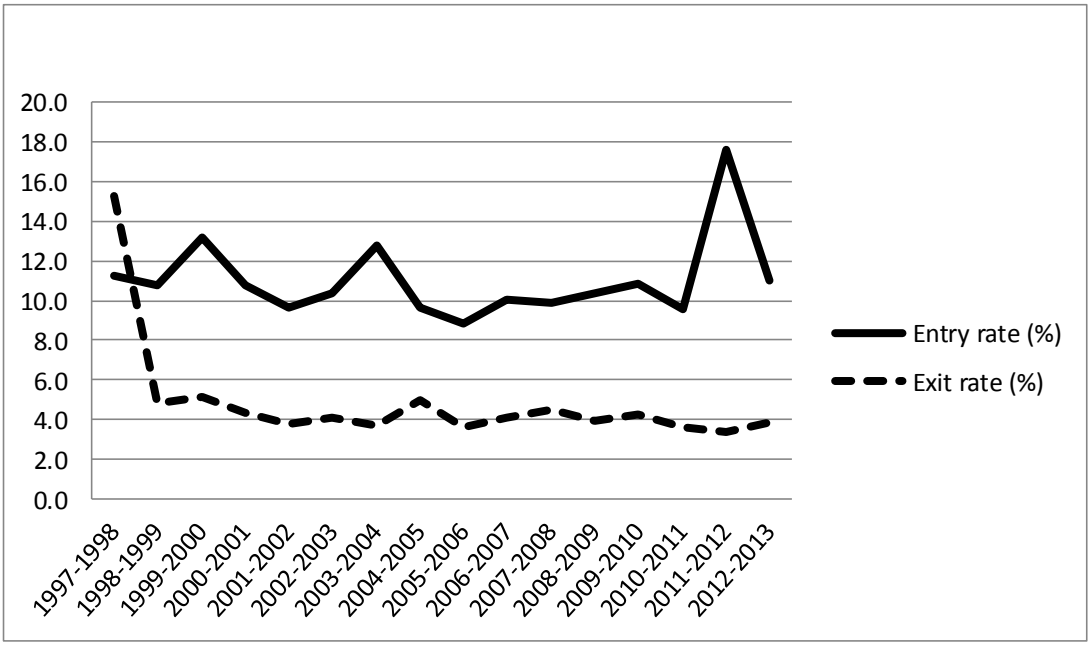
Although aggregate-level (country- or industry-level) exports continue to be highly dominated by a small number of large exporters, a significant number of firms enter export markets each year. As Table 1 indicated, the share of exporters out of the total number of firms in the dataset increased from 20.4% in 1997 to 22.6 % in 2013. When restricting the sample to only manufacturing firms, the share of exporters increased from 25.5% to 35.7% during the same period.

Figure 6 shows the export market entry and exit rates for the manufacturing sector. The export market entry rate is defined as the number of firms that started exporting in year t but did not export in year $t-1$ divided by the number of exporters in year t. The export market exit rate is defined as the number of firms that exported in year $t-1$ but did not export in year t divided by the number of exporters in year $t-1$. For each period, the export market entry rate is higher than the exit rate except for the 1997–1998 period.[12]

These data reveal that increasing numbers of firms began exporting, and the share of exporters has thus been rising. This trend may reflect the fact that more and more Japanese firms have become getting heavily involved in global value chains, as well as the fact that domestic market growth has been sluggish. However, as shown above, most Japanese firms, including exporters, have not seen remarkable improvements in productivity. In the next section, I investigate the effect of export market entry on firm productivity, with a particular focus on the catch-up by laggard firms to the productivity frontier.

[12] The high export market exit rate may be partly due to the Asian Economic Crisis in 1997.

Figure 6. Annual Export Market Entry and Exit Rates



Source: Author.

4. Effect of Export Market Entry on Ability to Catch-up to the National Productivity Frontier

A large body of literature has investigated the determinants of firm productivity growth. Technological capability development by learning from technology frontier firms and by receiving technology spillovers from other firms have been identified as drivers of firms' productivity growth. Moreover, factors such as pro-competitive market structure, learning-by-exporting, and proximity to and/or transactions with productive firms are likely to facilitate firms' efforts to improve productivity. This section examined the laggard firms' ability to catch-up to the productivity frontier firms within an industry, focusing on the catch-up toward national frontier exporters and participation in the global market. Possible reasons for the persistent productivity gap across firms and the overall low growth rate of productivity in Japan are then investigated.

Traditionally, the literature on macro-level economic development considers technology as diffusing from the technological frontier to laggard firms because of the

non-rival nature of technology. The process of macro-level productivity convergence and catch-up has been studied extensively in the field of economic growth and development (e.g. Barro and Sala-i-Martin 1991, 1992). Such a macro approach is based on the model of a representative firm; however, it is a well-known fact that firms and their growth processes are heterogeneous. To account for such heterogeneity, several studies, such as Bartelsman et al. (2008), Iacovone and Crespi (2010), and Andrews et al. (2015), examined the heterogeneous speed of convergence to the productivity frontier using firm-level data from various countries.

In this section, following the convergence model approach used by Bartelsman et al. (2008), I estimated the speed of convergence to the frontier for Japanese firms. In particular, I am interested in whether or not export market entry accelerates convergence to the frontier. Although each firm's efforts to extend their technological capabilities through R&D activities and innovation are likely to affect the convergence speed, a large body of literature on international economics suggests that economic interaction with global frontier technology via trade and foreign direct investment serves as an important channel of international technology diffusion. Therefore, I expect that export market entry should increase a firm's access to frontier technology and accelerate convergence to the frontier.

To measure the speed of convergence to the productivity frontier, following Bartelsman et al. (2008) and other previous studies, I estimated equation (1) below:

$$\Delta lnTFP_{i,s,t} = \alpha + \beta_1 Distance_{i,s,t-1} + \beta_2' X_{i,s,t} * Distance_{i.s.t-1} + \gamma \Delta lnTFP^{FR}_{i,s,t-1} + \eta' X_{i,s,t} + \phi lnRDINT_{i,s,t-1} + \delta_i + \sigma_s + \tau_t + \varepsilon_{i,s,t} \quad (1)$$

where the dependent variable is TFP growth for firm *i*, industry *s*, and year *t* (i.e. growth from year *t−1* to year *t*). The *Distance* term measures the lagged distance from the productivity frontier of industry *s*. The coefficient on *Distance* indicates the impact on TFP growth of an increase in firm distance to the frontier. I defined four types of frontier firms for each 2-digit industry: (1) top 10 exporters in terms of export volume, (2) top one percentile of exporters in terms of export volume, (3) top one percentile of

firms in the TFP distribution, and (4) top 10 percentile of firms in the TFP distribution. I considered both revenue TFP (markup not-corrected) and markup-corrected TFP. Frontier productivity is measured as frontier firms' mean TFP. Distance to the frontier is measured as the difference between a firm's TFP and frontier TFP as Log TFP of frontier firms minus log TFP of a non-frontier firm. In the case where a firm's TFP is higher than the mean of frontier firms' TFP, I defined the distance as zero. It has been noted that the larger the distance, the more laggard the firm. The frontier TFP one-year lagged growth rate is also included to control for each industry's growth potential.

X is a vector of export status variables: *Export_entry*, *Export_stop*, *Permanent_exports*, and *Export_switch*. To examine the effect after export market entry and exit, I construct *Export_entry* and *Export_stop* dummies following De Loecker and Warzynski (2012). In the case where a firm becomes an exporter in year t and continues exporting afterwards, *Export_entry* dummy takes one for this firm in year t and onwards until this firm stops exporting, and takes zero otherwise. For example, in the case shown in Appendix Table 3, the *Export_entry* dummy takes one for years $t = 3$ to $t = n$ for new exporters, and zero otherwise. In the case where an exporter stops exporting in year t and does not export in subsequent years, *Export_stop* dummy takes one for this firm in year t and onwards. Otherwise, the *Export_stop* dummy takes zero. In the case shown in Appendix Table 3, for example, the *Export_stop* dummy takes one for years $t = 3$ to $t = n$ for export market exiters and zero otherwise. I also constructed a *Permanent_exports* dummy, which takes one for firms that export in all the years in the dataset, and zero otherwise. The *Export_switch* dummy takes one for firms that enter and exit the export market more than twice during the period of analysis, and zero otherwise.

The coefficients on the interaction term of export status variables and *Distance* capture the heterogeneous speed of catch-up across firms with different export status. In particular, the coefficient on the interaction term of *Export_entry* dummy and *Gap* captures the difference in convergence speed after export market entry, and the coefficient on the interaction term of *Export_stop* dummy and *Distance* captures the difference in the speed after export market exit. For the stand-alone export status dummies, I included *Export_entry* and *Export_stop* only and exclude

Permanent_exports and *Export_switch* because the latter two dummies are perfectly correlated with firm fixed effects.[13]

I also included the log of R&D intensity (*lnRDINT*) and firm fixed effects (δ) to control for firm characteristics. The regression also controls for industry fixed effects (σ) and year fixed effects (τ).

Table 2 provides the estimation results of baseline equation (1) for the manufacturing firms.[14] The positive and significant coefficient on *Distance* implies that the larger the productivity gap with the frontier, the faster the subsequent TFP growth of laggard firms. The coefficient estimates suggest that a 1% larger gap is associated with a 0.4%–0.7% faster growth rate in the following period. If the trend in frontier productivity growth is positive, we would see the frontier pulling away from the remaining firms. That is, when the frontier becomes more productive and the distance between frontier and other firms increases, those other firms will close approximately 0.4%–0.7 (i.e. 40–70%) of the productivity gap that emerges in each period. Less productive firms will close the gap to a greater extent in absolute terms than the more productive firms, i.e. the less productive firms catch up to the frontier faster than firms closer to the frontier.

However, the estimated coefficient of frontier TFP growth is negative and significant in all the cases, meaning that frontier growth does not induce the subsequent growth of non-frontier firms. In other words, if both the coefficient of frontier TFP growth and the coefficient of *Distance* were positive and significant, non-frontier firms would grow following frontier growth, with faster growth exhibited by firms that are farther away from the frontier. However, the negative coefficient of frontier TFP growth suggests that non-frontier firms do not follow the frontier when the frontier grows more productive. When the frontier becomes less productive, the remaining firms become more productive, which shrinks the productivity gap. In such a case, a reduction in the productivity gap does not indicate a process where the frontier pulls the laggards, who catch up with the frontier.

[13] Summary statistics for the variables are shown in Appendix Table 4.
[14] The results for all the firms are shown in Appendix Table 5, which are consistent with the results in Table 2.

Quantitatively, for example, the estimation result of column (4) in Table 2 suggests that 1% larger distance to the frontier is associated with 0.7% faster growth rate in the following period. However, non-frontier firms' productivity will deteriorate by 0.4% on average when the frontier productivity increases by 1%. Therefore, in this case, frontier productivity growth does not necessarily result in the faster subsequent productivity growth of the laggard firms.

On the other hand, when frontier firms' productivity is deteriorated by 1%, it is associated with a 0.4% rise in productivity of non-frontier firms on average in the following period. However, in this case, the distance to the frontier was reduced and the productivity growth of the non-frontier firms will deteriorate. Although the productivity gap between the frontier and the non-frontier will shrink in this case, the decline in the frontier productivity may lead to a decline in non-frontier firms' productivity.

As shown in Appendix Table 7, for the 1997–2013 period, the annual average TFP growth rate of Japanese firms was very low at around 1–2%. Moreover, in the latter half of the period, i.e. 2005–2013, the annual average TFP growth rate was negative. Although this negative growth might be partly due to the 2008 global financial crisis, the frontier's very low or even negative growth did not greatly pull the laggard firms, which might be a possible reason for the persistent productivity gap and stagnant productivity growth observed for all firms.

Moreover, the estimated coefficient of *Export_entry* dummy is negative and significant in all cases except column (2), whereas the coefficient on the interaction term of *Export_entry* and *Distance* is positive and significant. These estimated coefficients suggest that the productivity growth rate of export starters does not improve after export market entry, but rather deteriorates, although only low-productivity firms realise higher productivity growth after export market entry.

Table 2. Baseline Regression Results: Manufacturing Firms

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable	dlnTFP(markup not-corrected)				dlnTFP(markup corrected)			
Frontier definition	Top10 exporters	Top 1% exporters	Top 1% productivity	Top 10% productivity	Top10 exporters	Top 1% exporters	Top 1% productivity	Top 10% productivity
L.Distance to Frontier	0.555***	0.423***	0.732***	0.702***	0.565***	0.451***	0.727***	0.695***
	(0.007)	(0.007)	(0.011)	(0.010)	(0.009)	(0.010)	(0.011)	(0.010)
L.lnRDINT	0.0761	0.179**	0.212**	0.191**	0.126	0.202**	0.132	0.137
	(0.073)	(0.091)	(0.095)	(0.092)	(0.086)	(0.086)	(0.089)	(0.090)
L.dlnTFP (Frontier)	-0.344***	-0.276***	-0.396***	-0.401***	-0.353***	-0.273***	-0.456***	-0.457***
	(0.007)	(0.005)	(0.010)	(0.010)	(0.008)	(0.006)	(0.010)	(0.010)
Export_entry*L.Distance	0.0242**	0.00961	0.0590**	0.0487**	0.0182	-0.0129	0.0607**	0.0492**
	(0.011)	(0.012)	(0.024)	(0.022)	(0.015)	(0.015)	(0.027)	(0.024)
Export_stop*L.Distance	0.0134	0.000414	0.0535*	0.0441*	0.00851	-0.0151	0.101***	0.0843***
	(0.013)	(0.013)	(0.029)	(0.027)	(0.017)	(0.017)	(0.033)	(0.030)
Permanent_exports*L.Distance	-0.00820	0.000111	0.0402	0.0369	0.0232	-0.0400*	0.0738**	0.0641**
	(0.018)	(0.016)	(0.028)	(0.025)	(0.022)	(0.021)	(0.029)	(0.026)
Export_switch*L.Distance	-0.0308	-0.0128	-0.0111	-0.0232	0.0207	-0.0107	0.0241	0.0190
	(0.024)	(0.022)	(0.036)	(0.033)	(0.033)	(0.030)	(0.040)	(0.038)
Export_entry	-0.0177***	-0.0127*	-0.0115**	-0.0118**	-0.0266***	-0.0117*	-0.0224***	-0.0234***
	(0.006)	(0.007)	(0.005)	(0.006)	(0.006)	(0.006)	(0.005)	(0.006)
Export_stop	-0.0127	-0.00351	-0.0130*	-0.0128*	-0.00306	0.00919	-0.0109	-0.0113
	(0.008)	(0.008)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
_cons	-0.0879***	-0.198***	0.0708***	0.0543***	0.0481***	-0.199***	0.146***	0.129***
	(0.005)	(0.005)	(0.004)	(0.004)	(0.006)	(0.005)	(0.005)	(0.005)
N	87894	66210	87894	87894	87894	66210	87894	87894
r2	.3	.263	.284	.295	.336	.303	.346	.355

Notes: Standard errors clustered at the firm level in parentheses. All equations include industry fixed effects and year fixed effects, but these are not reported. *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.
Source: Author.

To examine whether the catch-up speed differs across firms depending on their R&D efforts and export status, I included additional interaction terms of R&D intensity, export status, and *Distance*. The results shown in Table 3 confirm that less productive new exporters tend to close the gap with the frontier faster than more productive export starters, which is the same as the results presented in Table 2.[16] However, the coefficient of R&D intensity and distance tends to be negative, implying that more productive R&D firms are more likely to accelerate productivity growth than less productive R&D firms. Moreover, because the triple interaction terms of export status, R&D intensity, and *Distance* do not have a significant coefficient in any case except equation (6). I did not find any significant evidence that R&D firms catch up to the frontier faster than others after export market entry.

Therefore, I did not find any strong evidence for a catch-up process whereby frontier firms grow and pull the laggard firms. First, although less productive firms tend to close the gap with the productivity frontier more quickly, the productivity frontier itself shows very weak growth. Second, although less productive new exporters tend to have accelerated productivity growth compared to more productive new exporters, the productivity growth rate of new exporters deteriorates on average after export market entry. Thus, I did not find evidence of a strong pull by frontier firms. I also did not find whether entry to export markets strongly improves productivity growth.

[16] The results for all the firms are shown in Appendix Table 6, which are consistent with the results in Table 3.

Table 3. R&D and Catch-up to the Frontier: Manufacturing Firms

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable	dlnTFP(markup not-corrected)				dlnTFP(markup corrected)			
Frontier definition	Top10 exporters	Top 1% exporters	Top 1% productivity	Top 10% productivity	Top10 exporters	Top 1% exporters	Top 1% productivity	Top 10% productivity
L.Distance to Frontier	0.558***	0.425***	0.738***	0.708***	0.567***	0.456***	0.728***	0.696***
	(0.007)	(0.007)	(0.011)	(0.010)	(0.009)	(0.010)	(0.012)	(0.011)
L.lnRDINT	0.559***	0.444**	0.502***	0.533***	0.435**	0.699***	0.301*	0.324**
	(0.190)	(0.223)	(0.153)	(0.161)	(0.173)	(0.206)	(0.155)	(0.159)
L.lnRDINT*L.Distance	-0.530**	-0.341	-1.150*	-1.152*	-0.378	-0.719**	-0.183	-0.197
	(0.228)	(0.243)	(0.663)	(0.596)	(0.264)	(0.307)	(0.724)	(0.637)
L.dlnTFP (Frontier)	-0.344***	-0.276***	-0.395***	-0.401***	-0.353***	-0.273***	-0.456***	-0.457***
	(0.007)	(0.005)	(0.010)	(0.010)	(0.008)	(0.006)	(0.010)	(0.010)
Export_entry*L.Distance	0.0283**	0.0191	0.0693***	0.0569**	0.0189	-0.0120	0.0655**	0.0545**
	(0.012)	(0.013)	(0.025)	(0.023)	(0.016)	(0.017)	(0.029)	(0.026)
Export_stop*L.Distance	0.0161	0.00423	0.0457	0.0359	0.00669	-0.0151	0.0810**	0.0642**
	(0.014)	(0.014)	(0.032)	(0.029)	(0.019)	(0.019)	(0.036)	(0.032)
Permanent_exports*L.Distance	-0.0107	-0.0000829	0.0408	0.0356	-0.00167	-0.0571***	0.0458	0.0386
	(0.019)	(0.017)	(0.031)	(0.028)	(0.022)	(0.021)	(0.033)	(0.029)
Export_switch*L.Distance	-0.0267	-0.00976	-0.000228	-0.00976	0.0258	-0.00952	0.0312	0.0265
	(0.024)	(0.022)	(0.040)	(0.037)	(0.033)	(0.031)	(0.044)	(0.040)
Export_entry*L.lnRDINT*L.Distance	-0.180	-0.648	-0.212	-0.0621	0.0448	0.125	-0.298	-0.322
	(0.338)	(0.422)	(0.781)	(0.692)	(0.382)	(0.451)	(0.957)	(0.836)
Export_stop*L.lnRDINT*L.Distance	-0.109	-0.239	0.997	1.002	0.212	0.0748	1.882	1.866
	(0.476)	(0.569)	(1.206)	(1.108)	(0.607)	(0.769)	(1.719)	(1.508)
Permanent_exports*L.lnRDINT*L.Distanc	0.485	0.221	0.800	0.888	1.117***	1.138**	1.270	1.161
	(0.351)	(0.370)	(0.881)	(0.794)	(0.422)	(0.481)	(1.017)	(0.903)
Export_switch*L.lnRDINT*L.Distance	-0.0966	-0.170	-0.303	-0.529	-0.303	0.146	-0.569	-0.585
	(0.568)	(0.568)	(1.586)	(1.454)	(0.572)	(0.593)	(1.660)	(1.464)
Export_entry*L.lnRDINT	0.0210	0.272	0.0827	0.0571	-0.130	-0.257	-0.0267	-0.00823
	(0.246)	(0.282)	(0.220)	(0.227)	(0.237)	(0.240)	(0.262)	(0.266)
Export_stop*L.lnRDINT	-0.327	-0.0869	-0.379	-0.428	-0.319	-0.189	-0.434	-0.475
	(0.343)	(0.450)	(0.268)	(0.274)	(0.302)	(0.357)	(0.305)	(0.311)
Permanent_exports*L.lnRDINT	-0.421	0.0370	-0.0576	-0.127	-0.573**	-0.648**	-0.250	-0.275
	(0.275)	(0.317)	(0.225)	(0.230)	(0.243)	(0.306)	(0.228)	(0.233)
Export_switch*L.lnRDINT	-0.312	-0.175	-0.597**	-0.552*	-0.158	-0.278	-0.359	-0.371
	(0.370)	(0.408)	(0.284)	(0.297)	(0.367)	(0.407)	(0.345)	(0.366)
Export_entry	-0.0190***	-0.0169**	-0.0132**	-0.0134**	-0.0257***	-0.00996	-0.0224***	-0.0237***
	(0.007)	(0.008)	(0.006)	(0.006)	(0.007)	(0.007)	(0.006)	(0.006)
Export_stop	-0.00967	-0.00301	-0.00882	-0.00805	0.000241	0.0106	-0.00569	-0.00548
	(0.009)	(0.009)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
_cons	-0.0905***	-0.201***	0.0685***	0.0518***	0.0481***	-0.200***	0.146***	0.128***
	(0.005)	(0.005)	(0.004)	(0.004)	(0.006)	(0.005)	(0.005)	(0.005)
N	87894	66210	87894	87894	87894	66210	87894	87894
r2	.3	.263	.284	.295	.337	.303	.346	.356

TFP = Total Factor Productivity.

Notes: Standard errors clustered at the firm level in parentheses. All equations include industry fixed effects and year fixed effects, but these are not reported. *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

Source: Author.

5. Performance of Frontier Firms

The analysis in the previous section demonstrated that the sluggish productivity growth experienced by Japanese firms is partly attributable to the slow growth of national frontier firms. Although laggard firms that are farther away from the frontier tend to grow faster than firms closer to the frontier, the frontier's productivity growth is very low or even negative, and the pull from the frontier is rather weak.

These results suggest that the larger the productivity gap with the frontier, the faster the subsequent TFP growth of laggard firms. Quantitatively, a 1% larger distance is associated with 0.4%–0.7% faster growth rate in the following period, i.e. less productive firms catch up to the frontier faster than firms closer to the frontier. If the frontier becomes more productive and the rest follow, the frontier would pull more strongly on the firms farther away from the frontier, helping these laggards catch up to the frontier, resulting in growth for all the firms. However, the results of this paper, in fact, do not suggest that non-frontier firms follow the frontier when the frontier becomes more productive, and the results do not imply such a catch-up process in the case of Japan.

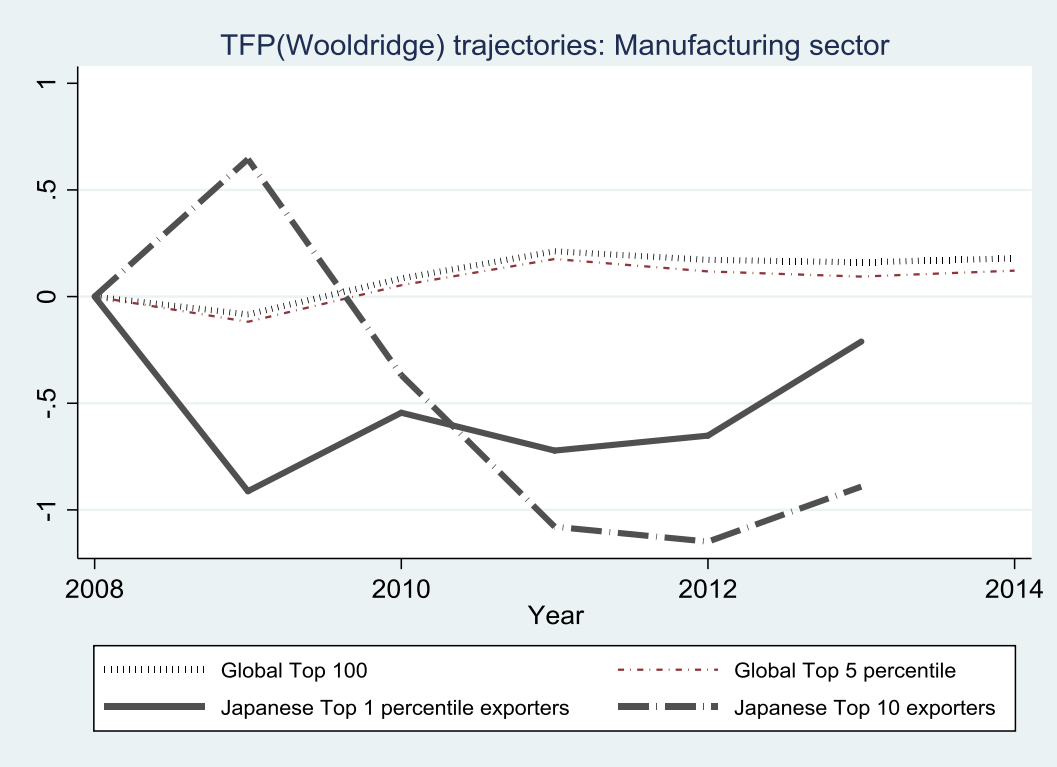
Thus, the overall productivity stagnation and persistent productivity gap between firms may reflect the fact that the pull from frontier firms is weak and the catch-up mechanism does not work. In this section, I examined frontier productivity and technological capabilities more closely.

It is not straightforward to compare the productivity level of firms across countries due to various data constraints, such as the availability of the appropriate currency conversion factors and comparable financial data. However, I roughly examined the productivity growth of Japanese top exporters and global frontier firms. Following Gal (2013), I utilised the ORBIS database provided by the Bureau van Dijk and calculated the average productivity of global frontier firms. Since ORBIS firm-level financial data are available only for the years 2008–2017 for this study, Figure 7 compares the evolution of the unweighted average of the estimated TFP (markup not-corrected) for

global frontier firms and top Japanese exporters since 2008.[17]

Although the figure should be interpreted with caution due to the various aforementioned data constraints, the productivity of Japan's top exporters clearly deteriorated significantly after 2008 compared to the global frontier's productivity. Although Japanese top exporters have seen their productivity recover in recent years, it had not attained 2008 levels as of the year 2013.

Figure 7. Productivity of Top Japanese Exporters vs. Global Frontier

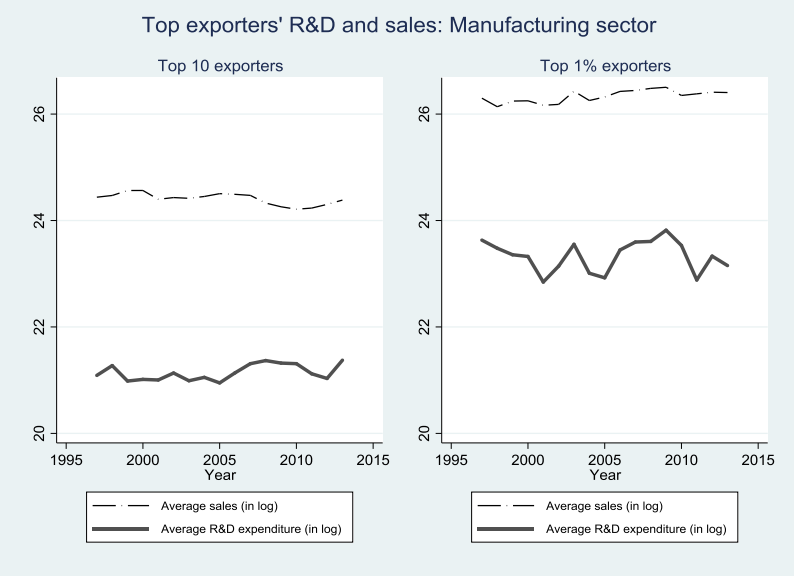


TFP = Total Factor Productivity.
Notes: The log TFP measure is normalised to 0 in 2008.
Source: Author.

[17] I defined global frontier firms as follows. I used ORBIS firm-level data for France, Germany, and the United Kingdom to calculate global frontier productivity, mainly because ORBIS database coverage is relatively high for these countries. In fact, because its coverage for the United States was very low, I therefore excluded US firms. The production function is estimated for each 2-digit industry for each country, and firm-level TFP is calculated using the MultiProd Version 1.1.2 Stata routines developed by the OECD MultiProd team. I converted firm-level financial data from local currencies to US dollars and calculate TFP using the average annual exchange rate, assuming that price level differences across these countries are not very great for the tradable manufacturing sector. After pooling firm-level TFP data for all three countries, the global frontier is defined as the top 5% of firms in terms of TFP levels within each 2-digit industry and year.

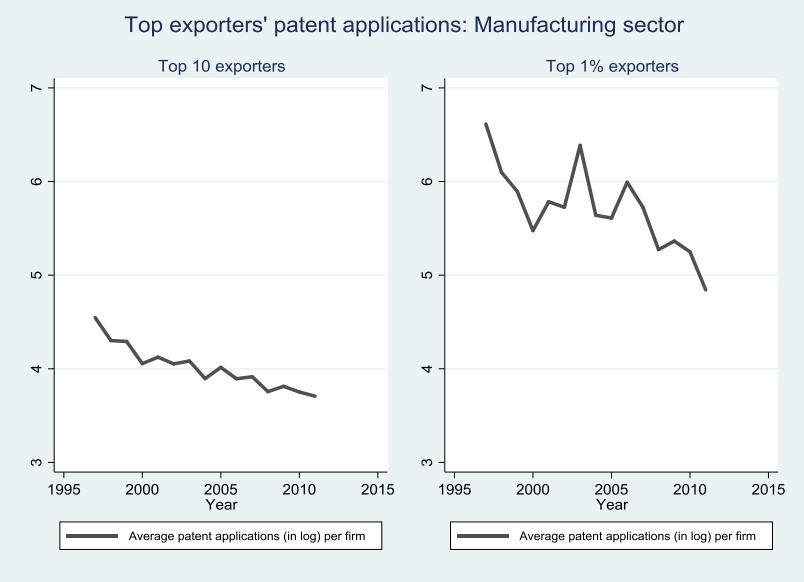
I also examined R&D inputs (R&D expenditure) and output (patents) for the top Japanese exporters. Panel (a) of Figure 8 shows average R&D expenditures (nominal values in logarithm) and average sales (nominal values in logarithm) for top Japanese exporters, and Panel (b) of Figure 8 shows the average number of patent applications per firm (in logarithm).[18] Although R&D expenditures do not decrease, the average number of patent applications has gradually declined. These figures may indicate that R&D efficiency has been deteriorating for the top Japanese exporters and that such declining R&D efficiency may be associated with sluggish productivity growth. Investigating the possible reasons why the number of patent applications has been declining and the relationship between patents and productivity stagnation is beyond the scope of this paper. However, this is an important issue that should be scrutinised in future studies.

Figure 8. Top Japanese Exporters' Technological Capabilities
Panel (a): R&D Expenditure and Sales



[18] I used the IIP Patent Database to calculate the number of patent applications for each firm and each year. The IIP Patent database can be downloaded from the Institute of Intellectual Property (IIP) website.

Panel (b): Patent Applications



Source: Author.

6. Conclusions

In this paper, firm-level panel data for Japan was used to examine between-firm productivity dispersion and explore whether export market entry improves productivity and accelerates productivity catch-up by new exporters toward the productivity frontier. Although productivity dispersion between high-productivity and low-productivity firms has not been clearly increased, particularly in the manufacturing sector, such dispersion remains large and persistent. More importantly, TFP growth has been very low and stagnant over time for both frontier and non-frontier firms. Although productivity dispersion per se may not be a problem, persistent dispersion combined with a low growth rate may reflect the fact that most Japanese firms do not exhibit much growth and that no productivity catch-up is being achieved by these laggard firms.

On the other hand, increasing numbers of firms started exporting, and the share of exporters has been increasing. However, the productivity of most Japanese firms, including exporters, has not improved to any substantial extent. Although export market entrants tend to be more productive than non-exporters, they remain less productive than permanent exporters and far less productive than top exporters. I also observed that the productivity gap between top exporters and other exporters is very large and significant.

Following the convergence model approach utilised by Bartelsman et al. (2008), I examined whether or not export market entry accelerates convergence to the productivity frontier. The results suggest that the larger productivity gap with the frontier, the faster the subsequent TFP growth of laggard firms. However, the results of this paper do not suggest that non-frontier firms follow the frontier when the frontier increases in productivity. Even though productivity growth tends to be higher for the firms more distant from the frontier, the non-frontier productivity growth rate deteriorates on average when frontier productivity rises. When frontier productivity declines, non-frontier productivity rises in the subsequent period. In this case, however, the distance between non-frontier and frontier firms shrinks, resulting in the frontier having a weaker pull.

Thus, according to this paper's findings, the large and persistent productivity gap between firms may reflect the facts that the pull of frontier firms is rather weak and the catch-up mechanism does not work. Moreover, even though quite a few firms start exporting every year and the number of exporters increases, the productivity growth rate of these new exporters deteriorates on average after export market entry. Further research is required to analyse why the catch-up mechanism does not work and why entry to export markets does not accelerate export starters' productivity growth.

The results of this paper may imply that in the case of Japan, the sluggish productivity growth exhibited by almost all firms may be attributed to the very low or even negative productivity growth of national frontier firms. I also found that Japanese top exporters have experienced sluggish productivity growth compared with global frontier firms. In addition, the technological capabilities of Japan's top exporting firms, measured as the number of patent applications, have been declining. Although I have not rigorously examined their distance from the global frontier and its determinants in this paper, the stagnant performance of Japan's top exporters might imply that technology and knowledge developed at the global frontier do not diffuse to Japanese frontier firms or to all other firms. Andrews et al. (2015) suggested that rising entry barriers and a decline in the contestability of markets hinder the process of technology diffusion from the global frontier to laggard firms. However, empirical evidence on a slowdown of this diffusion process remains very scarce.

Although this paper has not identified definitive reasons for the sluggish productivity growth of national frontier firms in the case of Japan, the results suggest that the weak pull by the national frontier could at least partly explain the persistent productivity gap between the frontier and laggards as well as the overall productivity stagnation of Japanese firms. Another finding of this paper, i.e. that the frontier's productivity growth is negatively associated with non-frontier firms' productivity, also raises questions regarding why non-frontier firms do not follow when the productivity of the frontier rises. Possible obstacles to technology diffusion from the frontier to the remaining firms remain another important issue worthy of attention in the future.

Moreover, this paper did not find strong evidence of productivity improvement after export market entry. As a result, the performance gap between the top and new exporters remains very large and persistent. The weak pull of top exporters or the national frontier may also result in the sluggish productivity growth of new exporters.

One policy implication of this paper is the importance of national frontier growth. As recent studies on the 'granular' economy have suggested, performance of the 'best' firms may be a key to assess a country's export competitiveness as well as act as a determinant of the country's macro-level economic performance. Therefore, it may be important to allow firms to grow large and expand trade (e.g. Di Giovanni and Levchenko, 2012; Di Giovanni, Levchenko and Méjean, 2014; and Freund and Pierola, 2015).[19] Encouraging exports by small and medium-sized enterprises (SMEs) may not have a large aggregate effect on a country's export competitiveness and overall productivity growth unless the government implements policy schemes that facilitate the growth of the national frontier as well as technology diffusion from the national frontier to laggards. Although better and higher quality education systems and R&D incentives would be important policy options, the government would need to consider the increasing potential for digital technologies to accelerate winner-takes-all dynamics or 'superstar effects' in the global market. Education and R&D policies responding to new/digital technologies and the globalised economy would be key to raise overall productivity.

[19] For a recent review of granular implications for trade, see Bernard, Jensen, Redding, and Schott (2015).

For the next step, it would be worthwhile to investigate the productivity gap between the national frontier and global frontier and examine the effects of export market status on the ability to catch-up to the global frontier. As Andrews et al. (2016) mentioned, the growing importance of tacit knowledge and the complexity of many technologies may allow only a few firms to hold such technologies, a situation that may hamper the ability of laggard firms to catch up to the frontier. Future research should investigate how such technological changes affect productivity catch-up behaviour by laggard firms toward frontier firms in the globalised economy.

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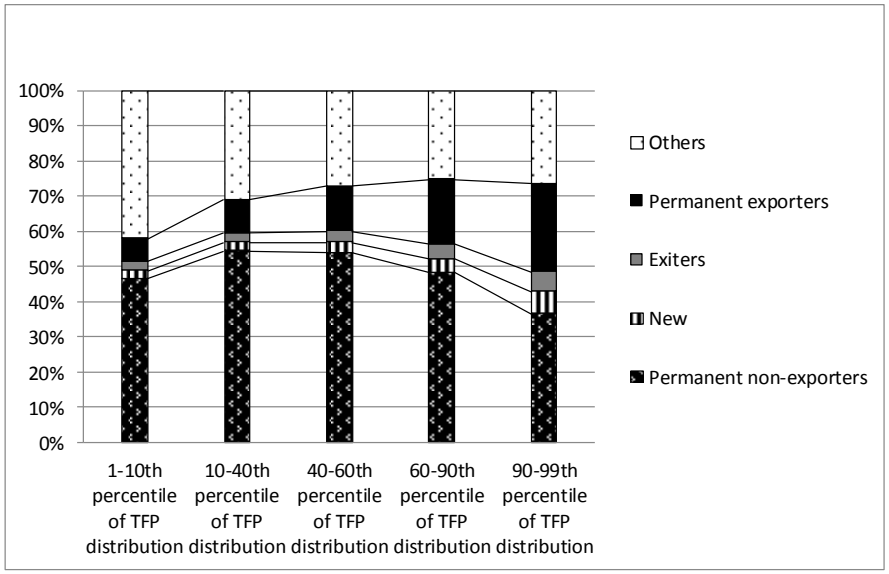
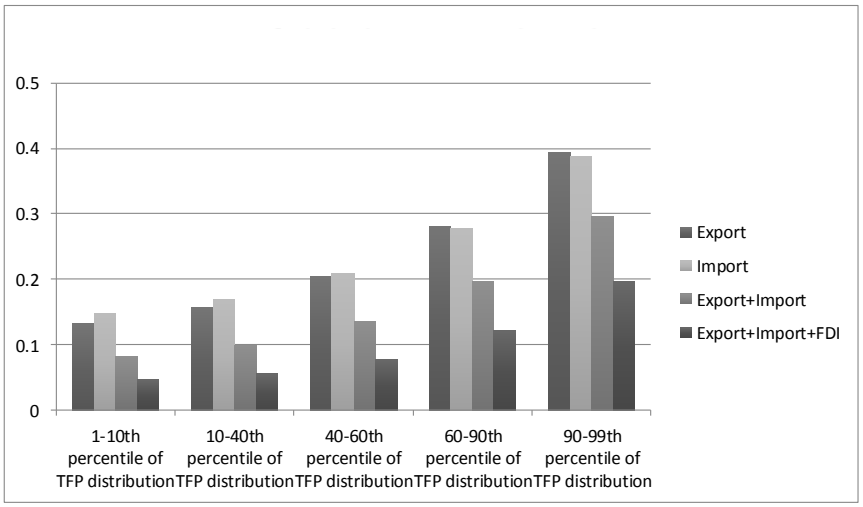
Appendix Figure 1. Productivity and Export Status, 1998–2012



TFP = Total Factor Productivity.
Source: Author.

Appendix Figure 2. Scope of Globalisation and Firm Productivity (Share of firms with international activities)



TFP = Total Factor Productivity.
Source: Author.

Appendix Table 1. Number of Observations by Industry

Year	All industries					Manufacturing					Wholesale & retail trade					Other services				
	Total	Goods exporters	(%)	Services exporters	(%)	Total	Goods exporters	(%)	Services exporters	(%)	Total	Goods exporters	(%)	Services exporters	(%)	Total	Goods exporters	(%)	Services exporters	(%)
1997	21,558	4,406	(20.4)	n.a.		11,052	2,814	(25.5)	n.a.		7,851	1,097	(14.0)	n.a.		800	39	(4.9)	n.a.	
1998	21,523	4,428	(20.6)	n.a.		11,081	2,844	(25.7)	n.a.		7,835	1,092	(13.9)	n.a.		869	46	(5.3)	n.a.	
1999	21,170	4,519	(21.3)	n.a.		10,936	2,934	(26.8)	n.a.		7,602	1,081	(14.2)	n.a.		897	53	(5.9)	n.a.	
2000	22,556	4,653	(20.6)	n.a.		10,720	3,013	(28.1)	n.a.		7,315	1,066	(14.6)	n.a.		2,095	102	(4.9)	n.a.	
2001	22,970	4,786	(20.8)	n.a.		10,673	3,091	(29.0)	n.a.		7,378	1,101	(14.9)	n.a.		2,493	112	(4.5)	n.a.	
2002	22,446	4,836	(21.5)	n.a.		10,393	3,103	(29.9)	n.a.		7,074	1,105	(15.6)	n.a.		2,402	111	(4.6)	n.a.	
2003	21,731	4,719	(21.7)	n.a.		10,037	3,074	(30.6)	n.a.		6,807	1,047	(15.4)	n.a.		2,473	113	(4.6)	n.a.	
2004	23,016	5,116	(22.2)	n.a.		10,627	3,353	(31.6)	n.a.		7,136	1,120	(15.7)	n.a.		2,701	134	(5.0)	n.a.	
2005	22,562	5,110	(22.6)	n.a.		10,437	3,364	(32.2)	n.a.		6,991	1,113	(15.9)	n.a.		2,832	133	(4.7)	n.a.	
2006	22,650	5,083	(22.4)	n.a.		10,321	3,347	(32.4)	n.a.		6,821	1,113	(16.3)	n.a.		3,056	137	(4.5)	n.a.	
2007	23,531	5,275	(22.4)	n.a.		11,399	3,816	(33.5)	n.a.		7,502	1,268	(16.9)	n.a.		3,242	146	(4.5)	n.a.	
2008	23,900	5,319	(22.3)	n.a.		11,519	3,849	(33.4)	n.a.		7,476	1,251	(16.7)	n.a.		3,463	164	(4.7)	n.a.	
2009	23,809	5,338	(22.4)	1,356	(5.7)	11,358	3,896	(34.3)	916	(8.1)	7,381	1,256	(17.0)	200	(2.7)	3,659	136	(3.7)	218	(6.0)
2010	24,398	5,543	(22.7)	1,539	(6.3)	11,480	4,013	(35.0)	1,022	(8.9)	7,608	1,332	(17.5)	240	(3.2)	3,805	136	(3.6)	247	(6.5)
2011	25,334	5,653	(22.3)	1,643	(6.5)	11,734	4,074	(34.7)	1,055	(9.0)	7,900	1,391	(17.6)	261	(3.3)	4,157	132	(3.2)	302	(7.3)
2012	29,142	6,511	(22.3)	1,872	(6.4)	13,223	4,647	(35.1)	1,214	(9.2)	9,174	1,650	(18.0)	282	(3.1)	4,973	152	(3.1)	345	(6.9)
2013	28,818	6,519	(22.6)	1,931	(6.7)	13,103	4,674	(35.7)	1,262	(9.6)	9,005	1,631	(18.1)	293	(3.3)	4,951	151	(3.0)	346	(7.0)
Total	401,114	87,814				190,093	59,906				128,856	20,714				48,868	1,997			

Source: Author.

Appendix Table 2. Definition of Export Status

	t-1	t	t+1
Permanent	YES	YES	YES
New	NO	YES	YES
Exiters	YES	YES	NO
Switchers	NO	YES	NO
Switchers	YES	NO	YES
…		…	
Switchers	YES	NO	NO
Non-exporters	NO	NO	NO

Note: YES means that the firm exports, and NO means that the firm does not export.
Source: Author.

Appendix Table 3. Definition of Export Status used in the Productivity Catch-up Analysis

	t=1	t=2	t=3	…	t=n-1	t=n
Permanent	YES	YES	YES	YES	YES	YES
New	NO	NO	YES	YES	YES	YES
Exiters	YES	YES	NO	NO	NO	NO
Switchers	NO	YES	NO	YES	NO	NO
Non-exporters	NO	NO	NO	NO	NO	NO

Note: YES means that the firm exports, and NO means that the firm does not export.
Source: Author.

Appendix Table 4. Summary Statistics

Panel (a) All Firms

Variable	Obs	Mean	Std. Dev.	Min	Max
dlnTFP(markup not-corrected)	204,981	0.0138	0.2044	-2.8500	2.8614
Distance to frontier (top 10 exporters, markup not-corrected)	275,646	0.5666	0.4971	0	3.2467
Distance to frontier (top 1% exporters, markup not-corrected)	209,423	0.6587	0.5327	0	3.3855
Distance to frontier (top 1% TFP, markup not-corrected)	275,646	0.1618	0.2255	0	1.8359
Distance to frontier (top 10% TFP, markup not-corrected)	275,646	0.1965	0.2485	0	1.9645
dlnTFP (frontier, top 10 exporters, markup not-corrected)	204,981	0.0111	0.1595	-0.6653	1.1478
dlnTFP (frontier, top 1% exporters, markup not-corrected)	155,321	0.0133	0.2367	-0.7098	1.3062
dlnTFP (frontier, top 1% TFP, markup not-corrected)	204,981	0.0144	0.0876	-0.7425	1.0122
dlnTFP (frontier, top 10% TFP, markup not-corrected)	204,981	0.0148	0.0883	-0.7539	1.0280
dlnTFP(markup corrected)	204,981	0.0221	0.2212	-2.1485	2.3308
Distance to frontier (top 10 exporters, markup corrected)	275,646	0.4361	0.4535	0	3.0274
Distance to frontier (top 1% exporters, markup corrected)	209,423	0.5097	0.4926	0	3.3012
Distance to frontier (top 1% TFP, markup corrected)	275,646	0.1645	0.2364	0	1.7090
Distance to frontier (top 10% TFP, markup corrected)	275,646	0.2004	0.2607	0	1.8352
dlnTFP (frontier, top 10 exporters, markup not-corrected)	204,981	0.0166	0.1620	-0.9168	1.3219
dlnTFP (frontier, top 1% exporters, markup not-corrected)	155,321	0.0177	0.2101	-0.7698	1.4808
dlnTFP (frontier, top 1% TFP, markup not-corrected)	204,981	0.0189	0.0974	-0.8082	1.1236
dlnTFP (frontier, top 10% TFP, markup not-corrected)	204,981	0.0192	0.0978	-0.8204	1.1330
Export_entry	275,646	0.0539	0.2258	0	1
Export_stop	275,646	0.0381	0.1915	0	1
Export_switch	275,646	0.0443	0.2057	0	1
Permanent_exports	275,646	0.1384	0.3453	0	1
lnRDINT	275,646	0.0062	0.0241	-0.0064	1.4923

Panel (b) Manufacturing Firms

Variable	Obs	Mean	Std. Dev.	Min	Max
dlnTFP(markup not-corrected)	111,956	0.0223	0.2176	-1.6560	1.9829
Distance to frontier (top 10 exporters, markup not-corrected)	146,721	0.5044	0.5211	0	3.2467
Distance to frontier (top 1% exporters, markup not-corrected)	115,482	0.5423	0.5841	0	3.3855
Distance to frontier (top 1% TFP, markup not-corrected)	146,721	0.1494	0.2152	0	1.8359
Distance to frontier (top 10% TFP, markup not-corrected)	146,721	0.1816	0.2375	0	1.9645
dlnTFP (frontier, top 10 exporters, markup not-corrected)	111,956	0.0198	0.1571	-0.6653	1.1478
dlnTFP (frontier, top 1% exporters, markup not-corrected)	86,351	0.0168	0.2856	-0.7098	1.3062
dlnTFP (frontier, top 1% TFP, markup not-corrected)	111,956	0.0230	0.1138	-0.7425	1.0122
dlnTFP (frontier, top 10% TFP, markup not-corrected)	111,956	0.0234	0.1145	-0.7539	1.0280
dlnTFP(markup corrected)	111,956	0.0329	0.2267	-2.1485	2.3308
Distance to frontier (top 10 exporters, markup corrected)	146,721	0.3557	0.4532	0	3.0274
Distance to frontier (top 1% exporters, markup corrected)	115,482	0.4004	0.5151	0	3.3012
Distance to frontier (top 1% TFP, markup corrected)	146,721	0.1461	0.2110	0	1.7090
Distance to frontier (top 10% TFP, markup corrected)	146,721	0.1779	0.2330	0	1.8352
dlnTFP (frontier, top 10 exporters, markup not-corrected)	111,956	0.0263	0.1716	-0.9168	1.3219
dlnTFP (frontier, top 1% exporters, markup not-corrected)	86,351	0.0245	0.2510	-0.7698	1.4808
dlnTFP (frontier, top 1% TFP, markup not-corrected)	111,956	0.0293	0.1262	-0.8082	1.1236
dlnTFP (frontier, top 10% TFP, markup not-corrected)	111,956	0.0295	0.1268	-0.8204	1.1330
Export_entry	146,721	0.0723	0.2591	0	1
Export_stop	146,721	0.0443	0.2059	0	1
Export_switch	146,721	0.0576	0.2330	0	1
Permanent_exports	146,721	0.1962	0.3971	0	1
lnRDINT	146,721	0.0098	0.0235	-0.0064	1.4923

TFP = Total Factor Productivity.
Source: Author.

Appendix Table 5. Baseline Regression Results: All Firms

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable	dlnTFP(markup not-corrected)				dlnTFP(markup corrected)			
Frontier definition	Top10 exporters	Top 1% exporters	Top 1% productivity	Top 10% productivity	Top10 exporters	Top 1% exporters	Top 1% productivity	Top 10% productivity
L.Distance to Frontier	0.507***	0.427***	0.707***	0.679***	0.561***	0.504***	0.724***	0.695***
	(0.005)	(0.005)	(0.008)	(0.008)	(0.006)	(0.006)	(0.008)	(0.008)
L.lnRDINT	0.101*	0.148*	0.163***	0.151***	0.124**	0.158**	0.114*	0.114*
	(0.052)	(0.082)	(0.057)	(0.056)	(0.061)	(0.079)	(0.058)	(0.058)
L.dlnTFP (Frontier)	-0.284***	-0.260***	-0.373***	-0.378***	-0.310***	-0.293***	-0.437***	-0.439***
	(0.005)	(0.004)	(0.009)	(0.009)	(0.005)	(0.005)	(0.009)	(0.009)
Export_entry*L.Distance	0.0329***	0.0137	0.0909***	0.0744***	0.0178	-0.0149	0.0819***	0.0678***
	(0.010)	(0.011)	(0.022)	(0.020)	(0.012)	(0.013)	(0.025)	(0.022)
Export_stop*L.Distance	0.0141	0.00169	0.0509**	0.0421*	0.0226	-0.00519	0.0861***	0.0737***
	(0.011)	(0.011)	(0.026)	(0.023)	(0.014)	(0.015)	(0.029)	(0.025)
Permanent_exports*L.Distance	0.0200	0.00508	0.0721***	0.0648***	0.0235	-0.0522***	0.0892***	0.0753***
	(0.015)	(0.014)	(0.025)	(0.023)	(0.017)	(0.017)	(0.026)	(0.023)
Export_switch*L.Distance	-0.00934	-0.0135	0.0109	-0.00306	0.0226	-0.0228	0.0472	0.0402
	(0.019)	(0.019)	(0.032)	(0.029)	(0.025)	(0.025)	(0.035)	(0.032)
Export_entry	-0.0175***	-0.0102	-0.0155***	-0.0156***	-0.0289***	-0.0183***	-0.0327***	-0.0336***
	(0.006)	(0.006)	(0.004)	(0.005)	(0.006)	(0.006)	(0.005)	(0.005)
Export_stop	-0.0134**	-0.00581	-0.0139**	-0.0143**	0.00476	0.0185***	-0.000153	-0.000826
	(0.007)	(0.007)	(0.006)	(0.006)	(0.006)	(0.007)	(0.006)	(0.006)
_cons	-0.192***	-0.230***	-0.00984***	-0.0282***	-0.0882***	-0.231***	0.0440***	0.0237***
	(0.004)	(0.004)	(0.003)	(0.003)	(0.004)	(0.004)	(0.003)	(0.003)
N	158350	119128	158350	158350	158350	119128	158350	158350
r2	.241	.218	.232	.243	.283	.263	.279	.291

TFP = Total Factor Productivity.

Notes: Standard errors clustered at the firm level in parentheses. All equations include industry fixed effects and year fixed effects, but these are not reported. *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

Source: Author.

Appendix Table 6. R&D and Catch-up to the Frontier: All Firms

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable	dlnTFP(markup not-corrected)				dlnTFP(markup corrected)			
Frontier definition	Top10 exporters	Top 1% exporters	Top 1% productivity	Top 10% productivity	Top10 exporters	Top 1% exporters	Top 1% productivity	Top 10% productivity
L.Distance to Frontier	0.508***	0.429***	0.708***	0.681***	0.561***	0.508***	0.724***	0.696***
	(0.005)	(0.005)	(0.008)	(0.008)	(0.006)	(0.007)	(0.009)	(0.008)
L.lnRDINT	0.207**	0.517**	0.298***	0.311***	0.241***	0.904***	0.180*	0.190*
	(0.081)	(0.220)	(0.095)	(0.105)	(0.077)	(0.208)	(0.096)	(0.104)
L.lnRDINT*L.Distance	-0.145	-0.499**	-0.426*	-0.406*	-0.188	-1.211***	-0.0592	-0.0791
	(0.157)	(0.233)	(0.233)	(0.223)	(0.200)	(0.307)	(0.287)	(0.258)
L.dlnTFP (Frontier)	-0.284***	-0.260***	-0.373***	-0.378***	-0.310***	-0.293***	-0.437***	-0.439***
	(0.005)	(0.004)	(0.009)	(0.009)	(0.005)	(0.005)	(0.009)	(0.009)
Export_entry*L.Distance	0.0352***	0.0205*	0.100***	0.0820***	0.0199	-0.0131	0.0875***	0.0735***
	(0.010)	(0.012)	(0.022)	(0.020)	(0.013)	(0.014)	(0.026)	(0.023)
Export_stop*L.Distance	0.0174	0.00434	0.0482*	0.0403*	0.0262*	-0.00288	0.0777**	0.0653**
	(0.011)	(0.012)	(0.027)	(0.024)	(0.015)	(0.015)	(0.031)	(0.027)
Permanent_exports*L.Distance	0.0221	0.0129	0.0822***	0.0730***	0.0129	-0.0499***	0.0746***	0.0627**
	(0.015)	(0.015)	(0.028)	(0.025)	(0.018)	(0.018)	(0.028)	(0.025)
Export_switch*L.Distance	-0.00612	-0.0107	0.0184	0.00582	0.0249	-0.0198	0.0534	0.0480
	(0.019)	(0.019)	(0.033)	(0.030)	(0.025)	(0.024)	(0.037)	(0.034)
Export_entry*L.lnRDINT*L.Distance	-0.180	-0.453	-0.582	-0.460	-0.138	0.280	-0.524	-0.520
	(0.324)	(0.432)	(0.506)	(0.451)	(0.370)	(0.455)	(0.704)	(0.610)
Export_stop*L.lnRDINT*L.Distance	-0.305	-0.183	0.489	0.363	-0.388	-0.121	1.155	1.146
	(0.424)	(0.550)	(0.863)	(0.724)	(0.580)	(0.777)	(1.457)	(1.208)
Permanent_exports*L.lnRDINT*L.Distance	0.0280	0.0300	-0.173	-0.0891	0.636	0.921*	0.723	0.645
	(0.311)	(0.368)	(0.612)	(0.559)	(0.387)	(0.485)	(0.729)	(0.657)
Export_switch*L.lnRDINT*L.Distance	-0.248	-0.0590	-0.449	-0.615	-0.137	0.354	-0.675	-0.850
	(0.531)	(0.607)	(1.137)	(1.066)	(0.527)	(0.663)	(1.438)	(1.336)
Export_entry*L.lnRDINT	0.0872	0.170	0.100	0.0745	0.105	-0.225	0.140	0.163
	(0.227)	(0.298)	(0.203)	(0.210)	(0.214)	(0.254)	(0.233)	(0.238)
Export_stop*L.lnRDINT	0.000167	-0.0575	-0.168	-0.186	-0.0761	-0.370	-0.239	-0.270
	(0.201)	(0.420)	(0.201)	(0.216)	(0.201)	(0.349)	(0.256)	(0.265)
Permanent_exports*L.lnRDINT	-0.0286	0.133	0.161	0.112	-0.337*	-0.603*	-0.130	-0.136
	(0.214)	(0.318)	(0.189)	(0.194)	(0.189)	(0.313)	(0.193)	(0.200)
Export_switch*L.lnRDINT	-0.142	-0.173	-0.393	-0.346	-0.374	-0.345	-0.378	-0.330
	(0.292)	(0.416)	(0.263)	(0.276)	(0.308)	(0.422)	(0.286)	(0.324)
Export_entry	-0.0186***	-0.0134*	-0.0167***	-0.0167***	-0.0302***	-0.0182***	-0.0341***	-0.0353***
	(0.006)	(0.007)	(0.005)	(0.005)	(0.006)	(0.007)	(0.005)	(0.005)
Export_stop	-0.0137*	-0.00593	-0.0125**	-0.0127**	0.00523	0.0207***	0.00205	0.00166
	(0.007)	(0.008)	(0.006)	(0.006)	(0.007)	(0.008)	(0.007)	(0.007)
_cons	-0.193***	-0.233***	-0.0110***	-0.0294***	-0.0878***	-0.234***	0.0441***	0.0238***
	(0.004)	(0.004)	(0.003)	(0.003)	(0.004)	(0.004)	(0.003)	(0.003)
N	158350	119128	158350	158350	158350	119128	158350	158350
r2	.241	.218	.232	.243	.283	.264	.279	.291

R&D = research and development; TFP = Total Factor Productivity.

Notes: Standard errors clustered at the firm level in parentheses. All equations include industry fixed effects and year fixed effects, but these are not reported. *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

Source: Author.

Appendix Table 7. Annual TFP Growth Rates

	Period 1997-2013		Period 1997-2005		Period 2005-2013	
	All	Manufacturing	All	Manufacturing	All	Manufacturing
All firms						
dlnTFP(markup not-corrected)	0.0138	0.0223	0.0304	0.0475	-0.0014	-0.0040
Frontier firms						
dlnTFP (top 10 exporters, markup not-corrected)	0.0111	0.0198	0.0313	0.0494	-0.0074	-0.0110
dlnTFP (top 1% exporters, markup not-corrected)	0.0133	0.0168	0.0337	0.0556	-0.0048	-0.0164
dlnTFP (top 1% TFP, markup not-corrected)	0.0144	0.0230	0.0327	0.0514	-0.0024	-0.0066
dlnTFP (top 10% TFP, markup not-corrected)	0.0148	0.0234	0.0333	0.0520	-0.0021	-0.0064
All firms						
dlnTFP(markup corrected)	0.0221	0.0329	0.0466	0.0663	-0.0004	-0.0019
Frontier firms						
dlnTFP (top 10 exporters, markup corrected)	0.0163	0.0263	0.0415	0.0574	-0.0063	-0.0061
dlnTFP (top 1% exporters, markup corrected)	0.0177	0.0245	0.0412	0.0683	-0.0031	-0.0131
dlnTFP (top 1% TFP, markup corrected)	0.0189	0.0293	0.0427	0.0639	-0.0030	-0.0067
dlnTFP (top 10% TFP, markup corrected)	0.0192	0.0295	0.0431	0.0640	-0.0028	-0.0065

TFP = Total Factor Productivity.
Source: Author.

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