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Abstract

This paper develops a framework that decomposes the international productivity gap of exporters into a selection effect and a competitiveness effect. This framework implies that the international productivity gap of exporters between two countries can be explained by three variables: the average productivity gap, the export participation rates, and the export premia within each country. The empirical analysis reveals that the exporters' productivity gap does not exclusively reflect the competitiveness of the industry, mainly because of the selection effect. These results imply that both the competitiveness and selection effects matter for explaining the cross-country productivity gap of exporters.

Keywords: International productivity gap, Exports, Competitiveness, Selection, Export premia
JEL classification: F1, D24

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1 Introduction

The international competitiveness of industries has long been one of the central issues in the business (e.g., Porter, 1990) and economics (e.g., Fagerberg, 1988) literatures. In measuring the international competitiveness of industries, previous studies have focused on exports and/or productivity (e.g., Dollar and Wolff, 1993). But beyond that, the performance of industries results from the performance of firms. In other words, the competitiveness of industries is ultimately attributable to the competitiveness of firms.

Recent studies on heterogeneous firms and international trade reveal a systematic relationship between the above two aspects: productive firms are more likely to be exporters.[1] The focus of these previous studies is, however, limited to the relationship between exports and productivity *within a country* rather than *between countries*. Although we now know that exporters outperform non-exporters, we do not know much about whether exporters from one country perform better than those from another country. The cross-country comparison of exporter performance has not yet been fully explored in the literature.

This paper focuses on the cross-country productivity gap of exporters and asks whether the productivity gap of exporters can be simply attributed to the average industry productivity differences between two countries. This question is important because the productivity of exporters certainly indicates the international competitiveness of firms.[2] According to Melitz (2003), for example, higher exporter productivity implies higher revenue, which results in higher (variable) profits. Moreover, this question is nontrivial because, as we will confirm, the productivity of exporters reflects not only the average level of productivity of the given industry but also trade costs. Yet no previous studies have answered the above question.

[1]For literature reviews on firm heterogeneity and exports, see Melitz and Redding (2015a).

[2]We use the productivity as a proxy for the international competitiveness. While this paper focuses on the productivity differences between developed countries, a caution may be needed to apply our framework to the comparison between developed and developing countries. This is because not only the differences in productivity but also the differences in factor prices could affect the international competitiveness.

This paper attempts to answer the above question by decomposing the overall productivity gap of exporters from two countries into two effects: the effect of selection into export markets (which we call the selection effect) and the effect of average industry productivity differences between two countries (which we call the competitiveness effect). Our framework implies that the international productivity gap of exporters between two countries can be explained by three variables: the average productivity gap between those countries, their export participation rates, and the export premia within each country. To test the empirical validity of these claims, we first utilize firm-level data from France and Japan. We then extend the analysis to cross-country comparisons of France, Japan, the United Kingdom, and the United States, obtaining the data from the literature (i.e., without accessing confidential, firm-level data directly).

We focus on French and Japanese firms for two reasons. First, the French and Japanese firm-level data are highly comparable, which is a prerequisite for measuring differences in productivity levels. This high degree of comparability allows us to construct two separate unbalanced panel datasets with the same coverage: the same period, the same industries, the same employment threshold, and the same definitions of inputs and output. Second, France and Japan can also be expected to exhibit substantial relative trade cost differences. French firms take advantage of being part of the European Union within which they can export at low costs. Japanese firms, however, must incur significant export costs because Japan maintains free trade agreements (FTAs) with a limited number of countries, let alone the fact that Japan is an island nation. This enables us to expect significant differences in the selection effects.

The analysis presented in this paper contributes to three strands of studies. The first strand is the literature on international productivity gaps. Some of these studies, such as Baily and Solow (2001), have compared the international productivity gap at the firm level, most of which have focused on large, listed firms. This choice precludes the ability to address the issue of firm export heterogeneity because most of these listed firms are exporters.[3] The second strand is the literature on firm heterogeneity and international trade. A number of studies have examined the relationship between firm productivity and exports in various countries. However, little attention has been paid to international comparison. To the best of our knowledge, only a study by Bellone et al. (2014) has directly compared the productivity of exporters (or non-exporters) between two different countries at the firm level.

The third strand is the literature on firm productivity distribution and trade. Many studies of firm heterogeneity and trade assume that the productivity and/or size of the firm follows a Pareto distribution. Some recent studies depart from this assumption. For example, Feenstra (2014) and Melitz and Redding (2015b) explore the properties of a bounded (or truncated) Pareto distribution, while Head et al. (2014) and Yang (2014) examine those of a log normal distribution. Like Head et al. (2014) and Yang (2014), this paper focuses on the log normal distribution of firm productivity and presents its useful properties. Our study will also contribute to the discussion of the firm productivity distribution and trade.

Building upon these strands of research, this paper takes a step toward deepening the understanding of the cross-country productivity gap of exporters. The latter is different from that of the usual exporter productivity premia, i.e. the productivity difference between exporters and non-exporters within a country. As we will see, because the export premia indicates the relative performance of exporters within a country, a larger export premia in one country does not necessarily imply the higher competitiveness of an exporter in that country. We also show that our analytical framework can be extended to the analysis of export premia. In that sense, our study extends international comparative studies on export premia, such as the one carried out by International Study Group on Exports and Productivity (ISGEP) (2008).

[3] Fukao et al. (2008) compared the productivity of listed firms in China, Japan, and South Korea. Fukao et al. (2011) extended this analysis by adding Taiwanese listed firms. Jung et al. (2008) and Jung and Lee (2010) compared the productivity of listed firms in Japan and Korea.

The rest of this paper is structured as follows. The next section explains our analytical framework, and we show that the international productivity gap of exporters can be decomposed into selection and competitiveness effects. Although several measures of firm competitiveness exist, this paper utilizes total factor productivity (TFP), following Dollar and Wolff (1993). Section 3 presents the data and the results. A summary of our findings and their implications is presented in the final section.

2 Analytical Framework

Starting from the pioneering models of Bernard et al. (2003) and Melitz (2003), a large class of models in this literature predicts that exporters should be more productive than non-exporters in any given country.[4] The simple prediction that exporters outperform non-exporters has received strong empirical support in a large variety of countries.[5]

We propose a simple framework that allows us to decompose the international productivity gap of exporters from two countries into two effects: the effect of selection into export markets and the effect of average industry productivity. We start by explaining the setup of our framework and then compare the productivity performance of exporters from two countries.[6]

[4] This simple prediction does not require that learning-by-exporting occurs, only that the costs of operating in domestic markets are lower than the costs of operating in foreign markets. Indeed, in the presence of trade costs and ex ante firm heterogeneity within industries, only the most productive firms within each industry will self-select into exporting. Obviously, if learning-by-exporting also prevails, as in the model by Clerides et al. (1998), the productivity gap between exporters and non-exporters may be even larger.

[5] See Greenaway and Kneller (2007), Wagner (2007, 2012) for a survey and Bellone et al. (2008) and Kimura and Kiyota (2006) for evidence from France and Japan, respectively.

[6] To simplify the analysis, we focus on exports rather than on other international activities, such as foreign direct investment (FDI) and outsourcing. Noting that many of FDI firms engage in exports (e.g., Kiyota and Urata, 2008) and that FDI firms and outsourcing firms are more productive than exporters (e.g., Kimura and Kiyota, 2006; Tomiura, 2007), exporters may include FDI firms and outsourcing firms.

2.1 Setup

Let ω_i be the logarithm of the productivity of firm i in an industry.[7] Let c_X be export costs incurred by firms. To cope with export costs c_X, firm efficiency must exceed the threshold productivity level ω_{c_X}. Denote the productivity of exporters and non-exporters as ω^X and ω^N, respectively. Assume that firm productivity ω_i can be approximated by a normal distribution with mean μ and standard deviation σ.[8] Whereas this assumption may not hold in practice, we take advantage of the simplifying normality assumption to derive a formal relationship between the differentiated export threshold values and the relative productivity gaps.[9]

This assumption has three advantages. First, as Head et al. (2014) noted, the log normal distribution fit the complete distribution of firm sales (rather than merely approximating the right tail). Indeed, the log normal distribution has been shown to capture the firm size distribution better than the Pareto distribution (e.g., Growiec et al., 2008). [10] Moreover, the log normal distribution maintains some desirable analytic features of the Pareto distribution. For example, raising the variables from the Pareto and log normal distributions to a power retains the original distribution.

Second, given a random variable such that $X \sim \aleph(\mu, \sigma)$, the parameters of the normal distribution μ and σ have direct empirical counterparts $\bar{X}$ and σ_X. Such statistics are readily available in the empirical literature on the productivity performance of exporters. Other parametric distributions, such as the Pareto or the Gamma distributions, may seem more appropriate. However, these distributions have parameters, the so-called shape and scale parameters, which do not correspond to simple empirical scalars. Third, the truncated

[7] In this section, the industry subscript is left out for ease of exposition.

[8] Hence this assumption means that productivity is log normally distributed.

[9] For example, Okubo and Tomiura (2014) found that the distribution of plant productivity was left skewed. Note, however, that their study focused on plant-level productivity rather than firm-level productivity.

[10] Moreover, the distribution of firm productivity does not necessarily have heavy tails.

mean for the normal distributions can be expressed in terms of the first two moments μ and σ only, whereas other distributions are less straightforward in the derivation of the truncated mean. In the following, we make use of this simplifying assumption and show that it allows for the use of very limited statistical information to compare countries' export performance.

Let μ^X be the average productivity of exporters. Under perfect sorting, all firms exceeding the threshold value export, whereas firms failing to reach the threshold focus on the domestic market. This result implies that the average productivity level of exporters in a given country is the following truncated mean:[11]

$$\mu^X = E(\omega^X) = E(\omega|\omega_i > \omega_{c_X}) = \mu + \sigma\frac{\phi(z)}{1-\Phi(z)}, \tag{1}$$

where $\phi(\cdot)$ and $\Phi(\cdot)$ are the probability density function and the cumulative distribution function, respectively, of the standard normal, and the superscript X denotes exporters. The variable z is defined as $z = \frac{(\omega_{c_X}-\mu)}{\sigma}$. The usual z statistics must be interpreted, in this case, as the threshold productivity level relative to the productivity distribution of the country. Note that the term $(1-\Phi(z))$ provides the export-participation rate, which is higher (lower) when ω_{c_X} is low (high), whereas $\Phi(z)$ provides the share of companies focusing exclusively on the domestic market.

Let $\lambda(z) = \frac{\phi(z)}{1-\Phi(z)}$, implying that the function λ is the hazard function of the standard normal distribution. Equation (1) can be rewritten as:

$$\mu^X = \underbrace{\mu}_{\text{competitiveness}} + \underbrace{\sigma\lambda(z)}_{\text{selection}}. \tag{2}$$

Equation (2) says that the average level of productivity for exporters ω^X is a function of three parameters: the average industry productivity μ of a given population of firms, the

[11]This relationship holds when the productivity distribution is normal. See, for example, Olive (2005, Chapter 4) for the case of exponential distribution and Cauchy distribution.

standard deviation σ of the distribution, and the hazard function $\lambda(\cdot)$. Because the first term reflects the productivity of all firms (i.e., both exporters and non-exporters), we call this the *competitiveness* of the industry. The second term reflects the truncation by the threshold productivity level. We thus call this the *selection* term.

Now let μ^N be the average productivity of non-exporters. As for the average productivity level of exporters, that of non-exporters is written as follows:

$$\mu^N = E(\omega^N) = E(\omega|\omega_i < \omega_{cX}) = \mu - \sigma\frac{\phi(z)}{\Phi(z)}, \tag{3}$$

where the superscript N denotes non-exporters. Then, the productivity export premia P_E^w, defined as the difference between the mean level of productivity of exporters and that of non-exporters within a country, is obtained by

$$P_E^w = \mu^X - \mu^N = \sigma\frac{\phi(z)}{[1-\Phi(z)]\Phi(z)}, \tag{4}$$

where P_E^w denotes the productivity premia of exporters over non-exporters within a country.

2.2 The international productivity gap between exporters from two countries

We now derive propositions on the international productivity performance between any pair of two small, open economies trading with the rest of the world. These two small, open economies are indexed as country 1 and country 2, and they differ both in terms of their underlying technology and trade costs.

The average productivity gap between country 1 and country 2 can be expressed as $P = E(\omega_1) - E(\omega_2)$, where $E(\omega)$ is the expected level of productivity for a given firm and $\omega = \ln TFP$. If firm productivity is distributed normally in both countries, one can write

$P = \mu_1 - \mu_2$, where μ_c represents the first moment of the normal distribution for country c ($\in \{1, 2\}$).

Let us denote $G_1(\omega_1)$ and $G_2(\omega_2)$ as the firm productivity distributions for country 1 and country 2, respectively. We assume that $G_1(\omega_1)$ and $G_2(\omega_2)$ are such that country 1 benefits from an average productivity advantage over country 2 as illustrated in Figure 1, i.e. distribution $G(\omega_1)$ stochastically dominates distribution $G(\omega_2)$.

[Figure 1 about here.]

Further, assume that export costs in country 1 are higher than those in country 2: $c_{X,1} > c_{X,2}$. Because $G(\omega_1) > G(\omega_2)$, this assumption does not eliminate the possibility that there are more firms exporting in country 1 relative to country 2. If $z_1 > z_2$, then $(1 - \Phi(z_1)) < (1 - \Phi(z_2))$, i.e. if the relative export threshold of country 1 exceeds that of country 2, then the participation rate of country 1 is lower than that of country 2. Given this framework, we obtain the following proposition.

Proposition 1: *The average productivity gap between exporters from two countries P_X is decomposed into the difference between the average productivity of firms in the two countries P and the difference between the hazard functions λ_c (country $c \in \{1, 2\}$).*

Proof: From equation (1) and the hazard function λ_c, we have:

$$\begin{aligned} P_X &= E(\omega_1 | \omega_{1,i} > \omega_{c_{X,1}}) - E(\omega_2 | \omega_{2,i} > \omega_{c_{X,2}}) \\ &= \underbrace{(\mu_1 - \mu_2)}_{=P} + \sigma_1\lambda_1 - \sigma_2\lambda_2 \\ &= \underbrace{P}_{\text{competitiveness}} + \underbrace{\sigma_1\lambda_1 - \sigma_2\lambda_2}_{\text{selection}}. \quad \blacksquare \end{aligned} \tag{5}$$

This proposition states that the productivity gap between exporters of two countries can be decomposed into two effects. One is the difference in competitiveness $P(= \mu_1 - \mu_2)$. We interpret this term as capturing the difference in competitiveness that may be attributable to various factors, such as differences in factor prices and technologies. The other is the difference between the selection effects ($\sigma_1\lambda_2 - \sigma_2\lambda_2$). The selection terms reflect the difference in the relative export thresholds.

One of the difficulties encountered in the international comparison of firm-level productivity is that, because of data confidentiality restrictions, one cannot simply merge two datasets into one unique dataset. However, the empirical validity of the proposition can be tested without violating the confidentiality of the data. Equation (5) indicates that three variables are needed to estimate the productivity gap between exporters from two countries: 1) the productivity gap of exporters P_X; 2) the productivity gap of all firms P; and 3) the standard deviations of the productivity distributions σ_c for country 1 and country 2. Note that these variables are the basic statistics (e.g., the means and standard deviations) of the productivity distributions, which can be retrieved separately from their respective datasets. Our analytical framework thus overcomes confidentiality restrictions in the sense that we can perform this analysis without pooling firm-level data from different countries.

The proposition implies that the productivity gap between exporters from two countries will be larger (smaller) if $\sigma_1\lambda_1 - \sigma_2\lambda_2 > 0$, (resp., < 0). For the illustrative purpose, suppose that $\sigma_1 = \sigma_2$.[12] One can show that $\lambda(z)$ is a monotonic transformation of z, so the following lemma can be obtained.

Lemma: *The average productivity gap between exporters from two countries P_X will be larger (smaller) than the difference between the average productivity of firms in the two countries P if the relative threshold value z_1 is greater (smaller) than z_2: $P_X > P$ if $z_1 > z_2$.*[13]

Proof: See Appendix A. ■

[12] This assumption will be relaxed in the empirical analysis.

[13] The condition holds as long as the relative standard deviation is smaller than the relative hazard function: $\sigma_2/\sigma_1 < \lambda_1/\lambda_2$.

The lemma states how the threshold productivity level affects the international productivity gap of exporters. The relative threshold value z_1 determines the participation rate of firms in international trade. Hence, the average productivity gap between exporters from country 1 and country 2 will exceed the average industry productivity gap when the participation rate of country 1 is lower than the participation rate of country 2.

Figure 1 illustrates this point. The figure displays the firm-level productivity distribution of two hypothetical countries, 1 and 2, with identical standard deviations but the mean value of the productivity of country 1, $E(\omega_1)$, lying to the right of the mean value of the productivity of country 2, $E(\omega_2)$. Assume further that the relative export threshold value z_1 is higher than the relative export threshold value z_2. This assumption implies that the export participation rate of country 1 is lower than the export threshold value of country 2. This relationship is illustrated by the shaded areas of the two productivity distributions, which display firms that export to foreign markets under perfect sorting. Figure 1 also shows the mean productivity of the exporters only. One easily observes that the productivity gap P_X is larger than the average industry productivity gap P because of the relative export threshold z, which is higher in country 1 than in country 2. Note that this mechanism can be inverted to show that $\lambda_1 < \lambda_2$ if $z_1 < z_2$, which in turn implies that $P_X < P$.

This mechanism is consistent with a large class of models of international trade with heterogeneous firms. The lemma states that in the presence of firm heterogeneity and differentiated trade costs across countries, the firm selection effect partly determines international productivity gaps. This mechanism could thus fit a large class of the models, including Melitz (2003)-type and Bernard et al. (2003)-type models. The mechanism is particularly consistent with models that explicitly feature country-specific trade costs, such as Helpman et al. (2008), or models that feature firm heterogeneity, comparative advantage, and country-specific trade costs, such as Bernard et al. (2007b).

2.3 Export premia and the export status of firms

In the literature on firm heterogeneity and international trade, understanding cross-country differences in export productivity premia, the productivity of exporters relative to non-exporters, is also an issue. For example, International Study Group on Exports and Productivity (ISGEP) (2008) organized a team consisting of more than 40 researchers from 14 countries to conduct a cross-country comparison of export premia for 14 countries. Our analytical framework can relate the selection effect to differences in export productivity premia.

From equation (5), we obtain the following corollary:

Corollary: *$P_X - P$ can be written as the difference of the export productivity premia. Therefore, the difference of the export premia between two countries is equivalent to the selection effect.*

Proof: Let μ_c, μ_c^X, and μ_c^N be the mean productivity of all firms, exporters, and non-exporters in country c, respectively. Note that export participation rate in country c is denoted as $(1 - \Phi_c)$. For ease of interpretation, let $\Omega_c \equiv (1 - \Phi_c)$ be the export participation rate. Then we have:

$$\begin{aligned} E(\omega_c|\omega_{c,i} > \omega_{c_X,c}) - E(\omega_c) &= \mu_c^X - \mu_c \\ &= \mu_c^X - \left\{\Omega_c\mu_c^X + (1 - \Omega_c)\mu_c^N\right\} \\ &= (\mu_c^X - \mu_c^N)(1 - \Omega_c) \\ &= P_{E,c}^w(1 - \Omega_c). \end{aligned} \tag{6}$$

Therefore, for countries 1 and 2, we have:

$$
\begin{aligned}
P_X - P &= [E(\omega_1|\omega_{1,i} > \omega_{1_X,1}) - E(\omega_1)] - [E(\omega_2|\omega_{2,i} > \omega_{2_X,2}) - E(\omega_2)] \\
&= (\mu_1^X - \mu_1) - (\mu_2^X - \mu_2) \\
&= P_{E,1}^w(1-\Omega_1) - P_{E,2}^w(1-\Omega_2). \qquad (7)
\end{aligned}
$$

Equation (7) states that $P_X - P$ can be written as the difference between the export premia of two countries $P_{E,c}^w$, where each export premium is the productivity gap between exporters and non-exporters weighted by each country's export participation rate Ω_c. Let P_E be the difference between the export premia of two countries:

$$
P_E = P_{E,1}^w(1-\Omega_1) - P_{E,2}^w(1-\Omega_2). \qquad (8)
$$

From equations (7) and (8), we have:

$$
\begin{aligned}
P_E &= P_X - P \\
&= \underbrace{\sigma_1\lambda_1 - \sigma_2\lambda_2}_{\text{selection}}, \qquad (9)
\end{aligned}
$$

which states that the difference of the export productivity premia P_E is equivalent to the selection effect. ■

2.4 Implications for a meta-analysis

One may be concerned that to document P_X and P, the distributions of firm productivity for countries 1 and 2 (i.e., $\sigma_{1,jt}$ and $\sigma_{2.jt}$) are needed. However, the distribution of firm productivity cannot be retrieved without accessing firm-level data. Indeed, one of the difficulties of cross-country comparison of firm productivity is that large-scale, firm-level data, which are usually owned by national statistical agencies, are confidential in many countries. It thus is a challenge to access to these firm-level data from outside the country.

Our analytical framework yields a useful implication for cross-country comparison of the productivity gap of exporters. Specifically, the following proposition can be obtained:

Proposition 2: *The international productivity gap between exporters from two countries P_X can be computed from the following three variables: 1) the industry average productivity gap P, 2) the export participation rate Ω, and 3) the export premium of each country P_E^w.*
Proof: From equations (5) and (7), we have:

$$\begin{aligned} P_X &= P + P_E \\ &= P + P_{E,1}^w(1-\Omega_1) - P_{E,2}^w(1-\Omega_2), \end{aligned} \tag{10}$$

where P is the industry average productivity gap, Ω_c is the export participation rate of country c, and $P_{E,c}^w$ is the export premium for country c. ■

Proposition 2 states that the international productivity gap of exporters P_X can be approximated, obtaining the relevant data from the literature (i.e., without accessing the confidential firm-level data directly). For example, for manufacturing as a whole, the industry average productivity gap P is available from the Groningen Growth and Development Center (GGDC) Productivity Level Database. Export participation rate Ω_c and export productivity premia P_E^w data are also available in the literature.

The following sections investigate the empirical validity of the above propositions and corollary. To estimate TFP, we employ the Wooldridge (2009) framework as a baseline, but also the method developed by Levinsohn and Petrin (2003) (hereafter, WLP). As robustness checks, we utilize a system GMM approach developed by Blundell and Bond (1998) (hereafter, BB) and the TFP index method developed by Good et al. (1997) (hereafter, GNS). Appendix B outlines the procedures followed to estimate the productivity measures.

3 Empirical Results

3.1 Data sources

To compare the firm-level productivity of two different countries, the vectors of firm inputs and output must be directly comparable. To meet this condition, we use the same firm-level data used in Bellone et al. (2014).[14] The French and Japanese firm-level data used in this study were collected by their respective national statistical offices. The data for France were drawn from the confidential *Enquête Annuelle d'Entreprises* (*EAE*), which is jointly prepared by the Research and Statistics Department of the French Ministry of Industry (SESSI) and the INSEE. This survey was conducted annually from 1984 until 2007. It gathers information from the financial statements and balance sheets of individual manufacturing firms and includes all of the relevant information needed to compute productivity indices, as well as information on the international activities of firms.

The data for Japan were drawn from the micro data of the *Kigyou Katsudou Kihon Chousa Houkokusho* (*Basic Survey of Japanese Business Structure and Activities*, *BSJBSA*), which is conducted annually by the Research and Statistics Department, METI (1994–2006). This survey was first conducted in 1991 and then annually since 1994. The main purpose of the survey is to statistically capture the overall picture of Japanese corporate firms in light of their activities in diversification, globalization, and strategies for R&D and information technology.

France and Japan conduct very similar firm-level surveys, so we can build a relevant set of comparable variables for the TFP computations using firm-level information: nominal output and input variables, industry-level data for price indices, hours worked, and depreciation

[14] We exclude outliers from the data used in Bellone et al. (2014). Specifically, we exclude firms whose log of output and inputs are in the bottom 1 percent.

rates.[15] The precise definition of each main variable and the methodology that we followed to ensure comparability across the French and Japanese data are fully described in Appendix C.

The data implementation step allows us to construct two separate unbalanced panel datasets with the same coverage to estimate the production function: the same period (1994–2006), the same industries, the same employment threshold (over 50 employees), and the same definition of inputs and output.[16] To convert the input and output series for France and Japan into common units, we use the industry-specific PPP series from the GGDC Productivity Level Database, which provides comparisons of output, inputs, and productivity at a detailed industry level for a set of 30 OECD countries.[17]

Table 1 presents the summary statistics for the productivity gaps of all firms and exporters in France and Japan. Productivity is estimated using the WLP framework. The productivity gap is measured by the productivity of Japanese firms relative to that of French firms. Therefore, the positive P means that Japanese firms are more productive than French firms in that industry, whereas the negative P means that French firms are more productive than Japanese firms. Similarly, the positive P_X means that Japanese exporters are more productive than French exporters in that industry.

[Table 1 about here.]

There are two notable findings in this table. First, although the signs of P and P_X are the same, their magnitudes are different. For example, in Textiles, P and P_X are 0.660 and 0.763, respectively. This means that the productivity gap of exporters is 10.3 percentage points greater than that of all firms. Similar patterns are confirmed in other industries. The

[15] Because of the high comparability of the firm-level data for Japan and France, a recent international comparative study by Dobbelaere et al. (2015) also used the *EAE* and *BSJBSA* data.

[16] Our data cover for the 1995–2006 period because the variables for 1994 are used only for lagged variables in the estimation.

[17] See Inklaar and Timmer (2008) for comprehensive descriptions of the database and the methodology followed to construct the PPP series.

results suggest that the productivity gap of exporters is not necessarily the same as that of all firms or of average industry productivity.

Second, the export participation rate, which is defined as the number of exporters divided by the number of all firms, is higher in France than in Japan in all 18 industries. The participation rate is between 71.8 and 95.9 percent for France, whereas the rate is between 6.9 and 50.4 percent for Japan. This result suggests that the trade costs are lower in France than in Japan.

3.2 International productivity gap of exporters, competitiveness, and selection

This section tests the empirical validity of Proposition 1 using French and Japanese firm-level data. Equation (5) can be written as

$$\begin{aligned} P_{X,jt} &= P_{jt} + \sigma_{1,jt}\lambda_{1,jt} - \sigma_{2,jt}\lambda_{2,jt} \\ &= P_{jt} + \sigma_{1,jt}\bar{\lambda}_1 + \sigma_{2,jt}\bar{\lambda}_2 + \varepsilon_{jt}, \end{aligned} \tag{11}$$

where $\varepsilon_{jt} = \sigma_{1,jt}\lambda_{1,jt} - \bar{\lambda}_1 - \sigma_{2,jt}\lambda_{2,jt} - \bar{\lambda}_2$, and $\bar{\lambda}_c$ is the average of $\lambda_{c,jt}$ over the industry and period.[18] By reparametrizing this equation and adding year fixed effects ν_t to control for unobserved year-specific shocks, we obtain

$$P_{X,jt} = \alpha_0 + \underbrace{\alpha_1 P_{jt}}_{\text{competitiveness}} + \underbrace{\alpha_2\sigma_{1,jt} + \alpha_3\sigma_{2,jt}}_{\text{selection}} + \nu_t + \varepsilon_{jt}, \tag{12}$$

where α is the empirical counterpart of $\bar{\lambda}$ expressed in equation (11). Variables $P_{X,jt}$, P_{jt}, $\sigma_{1,jt}$, and $\sigma_{2,jt}$ are obtained from the data. We expect that $\alpha_0 = 0$, $\alpha_1 = 1$, $\alpha_2 (= \bar{\lambda}_1) > 0$, and $\alpha_3 (= \bar{\lambda}_2) < 0$. Variables P_X and P are obtained by subtracting the industry averages

[18] A similar transformation has been employed by Klette (1999).

from firm-level TFP values. Therefore, we must first measure firm-specific, time-varying TFP measures and then construct the corresponding scalar for the computation of variables P_X and P.

Table 2 presents the estimation results for 18 industries from 1995 to 2006. The first, second, and third columns indicate the results of pooled OLS, fixed effects, and first-difference models, respectively.

[Table 2 about here.]

We highlight three important findings. First, regardless of the estimation method, the coefficients of the industry average productivity P (i.e. α_1 in equation (12)) are generally close to unity. Although the coefficients are significantly different from one statistically, this is consistent with Proposition 1. Second, in all estimation methods, the coefficient of σ_{JP} (i.e., α_2 in equation (12)) is positive, whereas the coefficient of σ_{FR} (i.e., α_3 in equation (12)) is negative. This result is also consistent with Proposition 1. Additionally, the constant term (α_0 in equation (12)) is insignificant for the fixed effect and first-difference models, which should be expected from equation (5).

The R-squared is 0.995 for the pooled OLS, 0.894 for the fixed effect, and 0.775 for first-difference models. In other words, by conservative estimates, nearly 80 percent of the variance in the productivity gap between exporters P_X from two countries can be explained by the competitiveness and selection effects. Taken together, these findings suggest that the cross-country productivity gap of exporters P_X cannot be explained by the average industry productivity P alone. Both competitiveness and selection effects matter in explaining the productivity gap of exporters.

One may argue that the selection effect may be different across export destinations. Indeed, Bellone et al. (2014) found that the average productivity gap of French and Japanese exporters varies across regions. In our framework, however, if we separate firms by their export destinations, it is not easy to find an appropriate control group because some firms export to multiple destinations. For example, we may treat exporters to North American as a treatment group. A possible control group could then consist of all non-exporters or of all non-exporters and exporters other than to North America. For these reasons, the differences by destination are not pursued here.

In sum, our analytical framework is well designed to explain the international productivity gap of exporters. Both selection and competitiveness matter for explaining the international productivity gap of exporters. Most of the variance in the international productivity gap between exporters from two countries can be explained by the first and second moments of the productivity distribution of firms.

3.3 Alternative measures of productivity

One may be concerned that our results are sensitive to the measure of productivity employed. To check the robustness of our results, we first recompute $P_{X,jt}$, P_{jt}, $\sigma_{1,jt}$, and $\sigma_{2,jt}$ in equation (12) using two additional measures of productivity.

The first measure is obtained by the BB method (i.e., system GMM). We first estimate TFP using the BB method, and we then reestimate equation (12). The definitions of variables and the sources of data are the same as those used in the previous subsection. A concern in the use of the WLP and BB methods is that the coefficients of the production function, or the technology parameters, are the same across firms within an industry. This may be a problem if, for example, small and large firms employ different technologies in a given industry.

To overcome this caveat, we adopt a second method, the so-called GNS index method. This method allows firms to employ different technologies within an industry. This method is based on the existence of a hypothetical reference firm for each industry characterized by the arithmetic mean values of log output, log input, and input cost shares for the firms in that industry in each year. Each firm's output and inputs are measured relative to this reference firm. The reference firms are then chain-linked over time. Hence, the index measures the TFP of each firm in year t relative to that of the reference firm in the initial year. A detailed description is presented in Appendix B. We first recompute $P_{X,jt}$, P_{jt}, $\sigma_{1,jt}$, and $\sigma_{2,jt}$ using the GNS method and then reestimate equation (12).

Table 3 presents the summary statistics of the international productivity gaps obtained for all firms and exporters using different measures of productivity: WLP, BB, and GNS. One notable finding is that the international productivity gaps of all firms and exporters vary by measure. For example, French exporters are more productive than Japanese exporters in 13 out of 18 industries based on the WLP method but they are more productive in 16 industries based on the BB method. Based on the GNS method, French exporters are more productive than Japanese exporters in 10 industries.

[Table 3 about here.]

Tables 4 and 5 present the regression results when TFP is estimated by the BB and GNS methods, respectively. Despite the fact that the international productivity gaps of all firms and exporters vary by measure (Table 3), the results of these alternative measures of productivity are strikingly close to those of the baseline results. Regardless of the productivity measures, all the coefficients exhibit the expected signs: $\alpha_0 \simeq 0$, $\alpha_1 \simeq 1$, $\alpha_2 > 0$, and $\alpha_3 < 0$. However, the significance levels vary slightly across measures and estimation methods. The R-squared is greater than 0.783, implying that the model explains at least 78 percent of the variance of P_X. Taken together, these results suggest that our main findings hold across the various measures of productivity.

[Table 4 about here.]

[Table 5 about here.]

3.4 Export premia and selection

The corollary states that the selection effect can affect the export premia. As in the test of Proposition 1, the empirical validity of the corollary can be tested by rewriting equation (9) as follows:

$$P_{E,jt} = \gamma_0 + \underbrace{\gamma_1 \sigma_{1,jt} + \gamma_2 \sigma_{2,jt}}_{\text{selection}} + \nu_t + \varepsilon_{jt}. \tag{13}$$

The variables $P_{E,jt}$, $\sigma_{1,jt}$, and $\sigma_{2,jt}$ are obtained from the data. We expect that $\gamma_0 = 0$, $\gamma_1 > 0$, and $\gamma_2 < 0$. The estimation of equation (13) enables us to examine the contribution of the selection effect to the international differences in the export premia. As previously done, we estimate equation (13), with OLS, fixed effects, and first-difference models. TFP is estimated by the WLP, BB, and GNS methods.

Table 6 presents the estimation results. Columns (1)–(3), (4)–(6), and (7)–(9) show the results for the WLP, BB, and GNS methods, respectively. Table 6 indicates that all the estimated coefficients are consistent with the theoretical predictions: $\gamma_0 \simeq 0$, $\gamma_1 > 0$, and $\gamma_2 < 0$. The R-squared values range from 0.074 to 0.381, depending on the estimation method and productivity measure. The results suggest that the selection effect matters in explaining the difference between the export premia of two countries, albeit to a lesser extent than the competitiveness effect.

[Table 6 about here.]

One may be concerned that the explanatory power is not sufficiently high. However, this simply means that much of the variation in P_X can be explained by differences in P. In other words, even when we focus on what has been left unexplained by P, the results are still generally consistent with the theoretical prediction. Needless to say, factors such as innovation activities and trade policies may be important factors in explaining the difference in the export premia (e.g., International Study Group on Exports and Productivity (ISGEP), 2008).

3.5 A meta-analysis

This section tests the empirical validity of Proposition 2. Due to the high comparability of the French and Japanese firm-level data, our analysis focused on the France-Japan comparison. However, as Proposition 2 states, our analytical framework can be extended to cross-country comparison without accessing confidential firm-level data directly. To estimate the international productivity gap of exporters P_X, only the industry average productivity gap P, export participation rate Ω_c, and export productivity premium P_E^w of each country are needed. For manufacturing as a whole, it is relatively easy to access these data.

We focus on France, Japan, the United Kingdom, and the United States, the reason being that such information is relatively easy to access. We obtain the industry average productivity gap P from Ministry of Economy, Trade and Industry (METI) (2013, Table I-1-3-2).[19] The export participation rates Ω_c and export productivity premia P_E^w are obtained from Bernard et al. (2007a) for the United States, from Bellone et al. (2014) for France and Japan, and from Greenaway and Kneller (2004) for the United Kingdom.

Ideally, the sample selection for the firm-level data across countries should be consistent, as in the previous sections. However, firm-level data are confidential in many countries, and thus, it is not easy to apply the same criteria across countries. Therefore, this exercise may be helpful for those who are interested in the international comparison of exporters' productivity but cannot access confidential firm-level data, although the results of this exercise should be interpreted with care.

[19] We rely on Ministry of Economy, Trade and Industry (METI) (2013) rather than the GGDC Productivity Level Database. The GGDC Productivity Level Database reported manufacturing productivity excluding electrical machinery. In contrast, Ministry of Economy, Trade and Industry (METI) (2013) computed manufacturing productivity including electrical machinery based on the GGDC Productivity Level Database.

The upper panel of Table 7 presents the results using equation (10).[20] The industry average productivity gaps and the productivity gaps of exporters are measured relative to the United States. Table 7 indicates, for example, that French firms are, on average, 11.0 percent less productive than their US counterparts, whereas UK firms are, on average, 11.7 percent less productive than US ones.

[Table 7 about here.]

Two findings appear immediately. First, the exporters' productivity gap for two countries does not necessarily reflect the industry average productivity gap. The productivity gap of exporters between French and US firms is 12.4 percent, which is larger than industry average productivity gap (11.0 percent). In contrast, the productivity gap of exporters between UK and US firms is 10.2 percent, which is smaller than the industry average productivity gap (11.7 percent). Hence, because the gap becomes smaller for exporters than for all firms, our framework suggests that UK firms face higher trade costs than French firms. This is plausible because of geographic and currency differences between France and the UK. Similar patterns can be observed for Japan.

Second, a higher export premium does not necessarily reflect high performance in exporters' productivity. For example, the export premium for the UK is 9.7 percent, whereas that for the United States is 2.0 percent. Nevertheless, the productivity of UK exporters is 10.2 percent lower than that of US exporters. This pattern is due to the higher industry productivity and trade costs of the United States than of the UK. This result clearly indicates that the international comparison of exporter productivity gaps is different from that of exporter productivity premia.

[20] Note that the export participation rate Ω and the export premia P_E^w for France and Japan in Table 7 are different from those presented in Table 1. This is because in Table 7, outliers are excluded. Note also that the difference in the industry average productivity gap P in Table 7 varies from Table 1. This may be attributed to differences in the sample selection of each data source. Consistency between the industry- and firm-level productivity gaps is itself an issue that is beyond the scope of this paper.

One may be concerned that the export participation rate is measured by the share of exporters rather than the volume of exports. The results may change if we use the share of exports to gross output instead of export participation rate. To address this concern, we also use the share of exports to gross output Ω'. Exports and gross output are manufacturing total in 2005 and are obtained from the World Input–Output Database (Timmer, 2012). The results are presented in the lower panel of Table 7. The results are qualitatively similar to those which are presented in the upper panel. Even when we focus on the volume of exports rather than the share of exporters, our main messages remain unchanged.

In sum, our framework presents plausible results even from a meta-analysis. The results suggest that our analytical framework is easily applicable to cross-country comparisons. The productivity differences of two exporters can be approximated once one obtains the industry average productivity gap, the export participation rate, and the export productivity premia for both countries.

4 Discussion and Conclusions

This paper focused on the cross-country productivity gap of exporters and asked whether the productivity gap between exporters can be simply attributed to average industry productivity differences between any two countries. This question is important because the productivity of exporters indicates the international competitiveness of firms. But apart from the latter, the average productivity of exporters is also a result of trade costs. Nevertheless to our knowledge, no existing studies have addressed the above issues.

In this paper, we have developed a model in which the international productivity gap of exporters can be decomposed into two effects: the effect of selection into the export markets (the selection effect) and the effect of the average industry productivity differences between two countries (the competitiveness effect).

Using highly comparable firm-level data from France and Japan, we show that the exporters' productivity gap between two countries does not necessarily reflect the competitiveness of the industry due to the selection effect. This result implies that both the competitiveness and selection effects matter in explaining the cross-country productivity gap between exporters. We also found that the selection effect matters in explaining the international gap between exporters' productivity premia. The major messages of the paper remain unchanged even when we use alternative measures of productivity. Our analysis explains almost 80 percent of the variance in the international productivity gap between French and Japanese exporters. The results suggest that our analytical framework is well designed to explain the international productivity gaps between exporters.

The selection effect reflects various trade costs. A decline in trade costs means that the threshold productivity level shift to the left. If, for example, country 1 in Figure 1 reduces its trade costs through free trade agreements while holding other conditions constant, then the number of exporters increases, which decreases the international productivity gap between exporters.

Our analytical framework also shows that the international productivity gap between exporters from two countries can be computed from the following three variables: the industry average productivity gap, the export participation rate, and the export premium of each country. This implies that the international productivity gap between exporters can be approximated after obtaining the relevant data from the literature. We extend our analysis to cross-country comparisons among France, Japan, the UK, and the USA. Similar to the firm-level analysis, we found that the exporters' productivity gap between two countries did not necessarily reflect the industry average productivity gap due to the selection effect. Our analytical framework provides a useful path for the cross-country comparison of exporters' productivity gaps.

In conclusion, there are several research issues for the future that are worth mentioning.

First, it is also interesting to examine the cross-country productivity gap of non-exporters because the reduction in the trade costs could also affect their productivity. Second, while our model is based on the assumption of perfect sorting, there are some firms that do not export even if they are productive in reality. Relaxing this assumption is an important step to broaden the applicability of our framework. Finally, it is important to extend our analysis to different productivity distributions to determine the robustness of our results. Some of these issues will be explored in the next stage of our research.

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A Proof of Lemma

To prove Lemma, we must show that:

$$\lambda_1 > \lambda_2 > 0 \quad \text{if} \quad z_1 > z_2.$$

Define $\lambda(z) : \Re \longrightarrow \Re^+$ such that $\lambda(z) = \frac{\phi(z)}{1-\Phi(z)}$, where $\phi(\cdot)$ and $\Phi(\cdot)$ are the probability density and the cumulative functions of the standard normal distribution, respectively, such that $z \sim \aleph(0,1)$. To prove that $\lambda_1 > \lambda_2$, $\forall\ z_1 > z_2$, and $z \in \Re$, we must show that the first derivative does not change sign and remains positive. The first derivative of $\lambda(z)$ with respect to z yields the following:

$$\frac{\mathrm{d}\lambda(z)}{\mathrm{d}z} = \frac{\phi'(z)[1-\Phi(z)] + \phi(z)^2}{[1-\Phi(z)]^2}. \tag{14}$$

Because of the squared terms, the denominator is always positive, so the sign of equation (14) depends entirely on the sign of the numerator. Because $\phi'(z) = -z\phi(z)$, we must therefore prove the following:

$$-z\phi(z)[1-\Phi(z)] + \phi(z)^2 > 0. \tag{15}$$

Dividing through by $-\phi(z)$ and solving for z yields the following necessary condition for

$\lambda(z)$ to be monotone and increasing in z:

$$z < \frac{\phi(z)}{1-\Phi(z)} = \lambda(z). \tag{16}$$

One must therefore envisage two situations:

1. $z \leq 0$. Because $\lambda(z) > 0 \quad \forall\, z \in \Re^-$, $z < \lambda(z)$ holds true, and $\mathrm{d}\lambda(z)/\mathrm{d}z > 0$

2. $z > 0$. To show that $z < \lambda(z)$, we have three necessary conditions: (i) the two asymptotic limits of $\lambda(z)$ are greater than z when $z \to +\infty$ and when $z \to 0$; (ii) the asymptotic limits of $\lambda(z)$ when $z \to +\infty$ exceeds that of $\lambda(z)$ when $z \to 0$; (iii) $\lambda(z)$ is monotone in between the two asymptotes. Let us start with the asymptotes:

   - $\lim_{z\to 0} \lambda(z) = \frac{\phi(0)}{1-\Phi(0)} = r$. Hence, $\lambda(z)$ is equal to a positive real number $r > z = 0$.
   - $\lim_{z\to+\infty} \lambda(z) = \frac{0}{0}$ and is undetermined. Using l'Hôpital's rule, one can write:

   $$\lim_{z\to+\infty} \frac{\phi(z)}{1-\Phi(z)} = \lim_{z\to+\infty} \sigma \frac{\phi(z)'}{[1-\Phi(z)]'} = \frac{-z\phi(z)}{-\phi(z)} = z = +\infty$$

   Because $r < +\infty$, $\lim_{z\to 0} \lambda(z) < \lim_{z\to+\infty} \lambda(z)$. Condition (i) and (ii) are thus verified.

   A far as condition (iii) is concerned, Thomas (1971) shows that a necessary condition for hazard function $\lambda(z)$ to be monotone is that its second derivative is log concave, that is, its second derivative must be negative. If $\phi(z) = 1/\sqrt{2\pi}e^{-(1/2z^2)}$, then:

   $$\frac{\mathrm{d}^2}{\mathrm{d}z^2} \ln \phi(z) = -1$$

   This implies that condition (iii) is verified. All three conditions (i)–(iii) imply that the second situation is verified, $z < \lambda(z) \quad \forall\, z \in \Re^+$.

The above implies that the numerator $-z\phi(z)[1-\Phi(z)]+\phi(z)^2$ is always positive. Therefore, $\lambda(z_1) > \lambda(z_2) \quad \forall\, z_1 > z_2$. Function $\lambda(z)$ is a monotonic function increasing in z. ■

B Measurement of Productivity

B.1 Wooldridge (2009)-Levinsohn and Petrin (2003) (WLP) method

In the baseline analysis, we employ the Wooldridge (2009) modification of Levinsohn and Petrin's (hereafter, WLP) framework. The WLP method is the one-step estimation procedure in the GMM framework, which is built on the Olley and Pakes (1996) (hereafter, OP) and Levinsohn and Petrin (2003) (hereafter, LP) approaches. It is also robust to the criticism of Ackerberg et al. (2006) (hereafter, ACF) on a technical issue. In addition, unlike the semi-parametric estimators (e.g., OP, LP), the WLP method also allows for the calculation of robust standard errors without bootstrapping. A brief summary for the WLP method follows.

Assume that the production function has a scalar Hicks-neutral productivity term and technology parameters that are common across firms. Thus, we have the following expression for the production function:

$$Q_{it} = F(L_{it}, K_{it}; \mathbf{B}), \tag{17}$$

where Q_{it}, L_{it}, and K_{it} are output (value added), capital stock, and labor input, respectively; $\mathbf{B}$ is a set of technology parameters to be estimated. Let q_{it} be the Cobb-Douglas production function:

$$q_{it} = \beta_l l_{it} + \beta_k k_{it} + \omega_{it} + \varepsilon_{it}, \tag{18}$$

where smaller cases indicate the log transform; ω_{it} is a measure of the true productivity, and ε_{it} is a true noise. If the inputs and output are measured in the same unit and the vector $\mathbf{B}$ is precisely estimated, then productivity ω_{it} is comparable between different countries.

The estimation of vector $\mathbf{B}$ is challenged by the correlation of variable input L with the productivity term ω_{it}, which is known by the entrepreneur but not by the econometrician.

The resulting endogeneity of labor L_{it} would yield inconsistent estimates for vector $\mathbf{B}$. To overcome this problem of endogeneity, we rely on a control function approach (e.g., the OP and LP methods) using demand for intermediate inputs to proxy for productivity:

$$m_{it} = m_t(k_{it}, \omega_{it}). \tag{19}$$

As in the OP method, one can then invert the function and write productivity ω_{it} as follows:

$$\omega_{it} = h(k_{it}, m_{it}). \tag{20}$$

As suggested by LP, under the assumption that

$$E(\varepsilon_{it}|k_{it}, l_{it}, m_{it}) = 0, \tag{21}$$

we can write the production function as follows:

$$\begin{aligned} E(q_{it}|l_{it}, k_{it}, m_{it}) &= \beta_l l_{it} + \beta_k k_{it} + h(k_{it}, m_{it}) \\ &= \beta_l l_{it} + g(k_{it}, m_{it}), \end{aligned} \tag{22}$$

where $g(k_{it}, m_{it}) \equiv \beta_k k_{it} + h(k_{it}, m_{it})$.

The LP method proposes to identify β_l using equation (21) in the first step. However, Ackerberg et al. (2006) suggests that l_{it} becomes a function of k_{it} and m_{it}, and β_l cannot be identified if l_{it} is chosen at the same time as intermediate inputs m_{it}. In the WLP method, as in the OP or LP methods, the following three assumptions are needed. First, ω_{it} follows a first-order of Markov process:

$$E(\omega_{it}|\omega_{i,t-1}, \cdots, \omega_{i,1}) = E(\omega_{it}|\omega_{i,t-1}). \tag{23}$$

Second, k_{it} does not immediately respond to innovations in productivity over last period's expectation a_{it}:

$$a_{it} \equiv \omega_{it} - E(\omega_{it}|\omega_{i,t-1}), \tag{24}$$

Finally, the conditional mean of productivity ω_{it} is expressed as:

$$E(\omega_{it}|\omega_{i,t-1}) \equiv f[h(k_{i,t-1}, m_{i,t-1})]. \tag{25}$$

Under these assumption, the productivity ω_{it} is expressed as:

$$\omega_{it} = a_{it} + f[h(k_{i,t-1}, m_{i,t-1})]. \tag{26}$$

Using this expression, the production function, equation (18), becomes:

$$q_{it} = \beta_l l_{it} + \beta_k k_{it} + f[h(k_{i,t-1}, m_{i,t-1})] + u_{it}, \quad t = 2, \cdots, T, \tag{27}$$

where $u_{it} \equiv a_{it} + \varepsilon_{it}$. The orthogonal condition for equation (27) is:

$$E(u_{it}|k_{it}, l_{i,t-1}, k_{i,t-1}, m_{i,t-1}, \cdots, l_{i,1}, k_{i,1}, m_{i,1}) = 0, \quad t = 2, \cdots, T. \tag{28}$$

To identify β_l and β_k, Wooldridge (2009) propose to approximate $f[h(k_{i,t-1}, m_{i,t-1})]$ as a polynomial and to estimate equation (22) using $k_{it}, l_{i,t-1}$ and a set of non-linear functions in $k_{i,t-1}$ and $m_{i,t-1}$ as instruments. We use Stata code for the production function estimation written by Petrin and Levinsohn (2012), which is available at Amil Petrin's website.[21]

[21] Although Wooldridge (2009) proposes to jointly estimate equations (22) and (27), we only use equation (27) following Petrin and Levinsohn (2012). This decision is made because if l_{it} and m_{it} are determined simultaneously, β_l cannot be identified by equation (22).

B.2 Blundell and Bond (2000) (BB) method (System GMM)

The other solution to an endogeneity problem is the use of instrumental variables. Blundell and Bond (2000) (hereafter, BB) applied the error component models suggested by Blundell and Bond (1998) to the production function estimation, which is summarized below.

Assume that the production function is of a Cobb-Douglas type and the technology term is composed of three factors:

$$\begin{aligned} q_{it} &= \beta_l l_{it} + \beta_k k_{it} + \omega_i + \omega_{it} + \epsilon_{it}, \\ \omega_{it} &= \rho \omega_{i,t-1} + \eta_{it}, \end{aligned} \tag{29}$$

where ω_i is an unobserved time-invariant, firm-specific effect; ω_{it} is an autoregressive productivity shock; η_{it} is an idiosyncratic productivity shock; and ε_{it} captures measurement error. Taking a lag of equation (29), we can derive the following dynamic representation:

$$q_{it} = \rho q_{it} + \beta_l (l_{it} - \rho l_{i,t-1}) + \beta_k (k_{it} - \rho k_{i,t-1}) + \underbrace{\omega_i (1-\rho)}_{\omega_i^*} + \underbrace{(\eta_{it} + \varepsilon_{it} - \rho \varepsilon_{i,t-1})}_{\varepsilon_{it}^*}. \tag{30}$$

To estimate this function, one straight forward approach is to take first differences, eliminate a firm fixed effect ω_i^* and use lagged levels of input and output variables as instruments. The difference in composite error $\Delta\varepsilon_{it}^*$ is uncorrelated with inputs and output lagged three or more periods lagged, as $\Delta\varepsilon_{it}^*$ contains data as far back as $\varepsilon_{i,t-2}$. However, this approach is known to be unsuccessful. Blundell and Bond (1998) theoretically show that these instruments are weak. This is because the first differences of the variables and their lagged values have weak correlations due to serial correlation of the variables.

To address these problems, BB propose to estimate the production function as a system combining the first-differenced and level equations. While lagged levels of labor and capital are used as instruments for the first-differenced equation, lagged first differences are used for the equation in levels.[22]

According to Van Biesebroeck (2007), which compares the various estimation methods of TFP, system GMM provides the most robust productivity estimates when there is measurement error or heterogeneity in terms of production technology. One disadvantage of this methodology is that it requires at least four time periods because the first-differenced equation contains one- and two-year lagged variables as well as current year variables. This in turn means that variables lagged more than two years are used as instruments.

B.3 Good et al. (1997) (index) method

The original Good et al. (1997) methodology is based on the existence of a hypothetical reference firm for each industry characterized by the arithmetic mean values of log output, log input, and input cost shares for the firms belonging to that industry in each year. Each firm's output and inputs are measured relative to this reference firm. The reference firms are then chain-linked over time. Hence, the index measures the TFP of each firm in year t relative to that of the reference firm in the initial year ($t = 0$).

Let ω_{it} and ω_{rt} be (the log of) TFP for firm i and the reference firm r, respectively, operating in year t in a given industry. We omit the industry subscript for simplicity of notation. The GNS index defines the TFP for firm i operating in year t as follows:

$$\begin{aligned}\omega_{it} - \omega_{r0} \simeq & (y_{it} - \bar{y}_{rt}) + \sum_{\tau=1}^{t} (\bar{y}_{r\tau} - \bar{y}_{r\tau-1}) - \sum_{x\in\{k,l,m\}} \frac{1}{2} (s_{ixt} + \bar{s}_{rxt}) (x_{it} - \bar{x}_{rt}) \\ & + \sum_{\tau=1}^{t} \sum_{x\in\{k,l,m\}} \frac{1}{2} (\bar{s}_{rj\tau} + \bar{s}_{rx\tau-1}) (\bar{x}_{r\tau} - \bar{x}_{r\tau-1}), \qquad (31)\end{aligned}$$

where y_{it}, x_{it}, and s_{it} are the log output, the log input of factor x, and the cost share of factor x, respectively for firm i; $\bar{y}_{rt}$, $\bar{x}_{rt}$, and $\bar{s}_{rxt}$ are the same variables for the reference firm

[22] We also utilize year dummies as instruments for the first-difference equation.

r and are equal to the arithmetic mean of the corresponding variable over all firms operating in year t.

The first term of the first line indicates the deviation of firm i's output from the output of the reference firm in year t. The second term represents the cumulative change in the output of the reference firm from year 0 to year t. The same operations are applied to each input x in the second and third lines, weighted by the average of the cost shares.

We extend the GNS index to international firm-level comparisons using a common reference firm to compile the relative TFP indices for firms in different countries. To begin, suppose that all of the relevant firm-level variables are expressed in common units irrespective of the country. Let us then focus on one industry and two countries: France (FR) and Japan (JP). Define France as the country of reference. The individual relative TFP indices for Japan can be computed using the following equation adapted from equation (31):

$$\begin{aligned}
\omega_{it}^{JP} - \omega_{r0}^{FR} \simeq\; & \left(y_{it}^{JP} - \bar{y}_{rt}^{FR}\right) + \sum_{\tau=1}^{t} \left(\bar{y}_{r\tau}^{FR} - \bar{y}_{r\tau-1}^{FR}\right) \\
& - \sum_{x\in\{k,l,m\}} \frac{1}{2}\left(s_{it}^{JP} + \bar{s}_{rt}^{FR}\right)\left(x_{it}^{JP} - \bar{x}_{rt}^{FR}\right) \\
& + \sum_{\tau=1}^{t} \sum_{x\in\{k,l,m\}} \frac{1}{2}\left(\bar{s}_{r\tau}^{FR} + \bar{s}_{r\tau-1}^{FR}\right)\left(\bar{x}_{r\tau}^{FR} - \bar{x}_{r\tau-1}^{FR}\right),
\end{aligned} \tag{32}$$

where y_{it}^{JP}, x_{it}^{JP}, and s_{it}^{JP} are defined as previously but are now specific to Japan; $\bar{y}_{rt}^{FR}$, $\bar{x}_{rt}^{FR}$, and $\bar{s}_{rt}^{FR}$ are the same variables for the French reference firm operating in year t and equal the arithmetic means of the corresponding variables for all French firms operating in year t. Note that we do not need to merge firm-level datasets for both countries; we need to exchange the information on French and Japanese reference firms. We can then establish a firm-level comparison between two countries while adhering to confidentiality restrictions.

C Main Variables for the Computation of Total Factor Productivity

Output is defined as total nominal sales deflated using the industry-level gross output price indices drawn respectively from *INSEE* for France and from the Japan Industrial Productivity (JIP) 2009 database for Japan.[23]

Labor input is obtained by multiplying the number of employees by the average hours worked by industry. Industry-level hours worked data are drawn from the EU-KLEMS dataset of the GGDC for France and from the JIP 2009 database for Japan.[24] Note that in France, a large decrease in hours worked occurred beginning in 1999 because of the 35-hour/week policy: hoursworked fell from 38.39 in 1999 to 36.87 in 2000.

The variables for intermediate inputs are available both in the *EAE* and in the *BSJBSA* surveys. In both surveys, intermediate inputs are defined as the operating costs (= sales costs + administrative costs) − (wage payments + depreciation costs). The inputs are deflated using the industry price indices for intermediate inputs published by *INSEE* for France and by the JIP 2009 database for Japan.

The capital stocks are computed from investment and book values of tangible assets following the traditional perpetual inventory method (the industry subscript j and the country superscript c are discarded to simplify the notation):

$$K_{it} = K_{it-1}(1 - \delta_{t-1}) + I_{it}/p_{It}, \tag{33}$$

where K_{it} is the capital stock for firm i operating in year t, δ_{t-1} is the depreciation rate in

[23] The JIP database has been compiled as a part of a project of the Research Institute of Economy, Trade, and Industry (RIETI) and Hitotsubashi University. For more details about the JIP database, see Fukao et al. (2007).

[24] Concordance between the industry-level EU-KLEMS database and the firm-level *EAE* database is ensured through the ISIC codes.

year $t-1$, I_{it} is the investment of firm i in year t,[25] and p_{It} is the investment goods deflator for industry j.[26] Both the investment price indices and the depreciation rates are available at the two-digit industrial classification level. They are drawn from the JIP 2009 database for Japan and from the INSEE series for France. Investment flows are traced to 1994 for incumbent firms and to the year of entry for firms that entered our dataset after 1994.

The cost of intermediate inputs is defined as the nominal cost of intermediate inputs while that of labor is the wage payments. To compute the user cost of capital (i.e., the rental price of capital) in country c, we use the familiar cost-of-capital equation given by Jorgenson and Griliches (1967) (the industry subscript j and the country superscript c are discarded to simplify the notation):[27]

$$p_{Kt} = p_{It-1}\tilde{p}_{Kt} + \delta_t p_{It} - [p_{It} - p_{It-1}]. \tag{34}$$

This formula shows that the rental price of capital p_{Kt} is determined by the nominal rate of return ($\tilde{p}_{Kt}$), the rate of economic depreciation and the capital gains. The capital revaluation term can be derived from investment price indices. To minimize the impact of sometimes volatile annual changes, three-period annual moving averages are used. The nominal rates of return are yields on the 10-year bonds of the French and Japanese governments.

[25] Investment data are not available in the *BSJBSA*. We thus use the difference in nominal tangible assets between two consecutive years as a proxy for nominal investment.

[26] If firm i's investment was missing in year t, we code firm i as having made no investment, i.e., $I_{it} = 0$.

[27] Ideally, this equation should be augmented to take into account business income taxes. However, as taxation regimes differ across France and Japan, we prefer, as in Inklaar and Timmer (2008), to rely on a simpler common formula abstracting from taxation.

Table 1: Summary Statistics

Industry	N_{JP}	Ω_{JP}	N_{FR}	Ω_{FR}	P	P_X	σ_{JP}	σ_{FR}
All manufacturing	405	31.7	397	86.7	0.169	0.369	0.529	0.431
Textile	226	18.6	408	88.5	0.660	0.763	0.414	0.448
Clothing	225	8.7	448	77.9	0.783	0.945	0.482	0.489
Manufacture of wood	94	7.4	182	74.9	-4.017	-4.151	0.477	0.403
Pulp and paper	275	9.5	283	91.7	1.413	1.872	0.640	0.406
Printing and publishing	503	6.9	464	71.8	-1.108	-1.069	0.466	0.575
Chemical products	631	50.4	626	94.1	0.319	0.506	0.622	0.591
Rubber and plastic	449	27.9	604	88.3	-1.453	-1.213	0.428	0.389
Non-metallic mineral products	367	21.1	324	75.5	0.451	0.778	0.502	0.403
Basic metal products	493	27.6	263	93.3	1.013	1.164	0.556	0.375
Fabricated metal products	643	22.8	913	85.9	-0.536	-0.455	0.409	0.295
Machinery and equipments	903	49.6	936	89.3	0.219	0.328	0.435	0.375
Machinery for office and services	104	36.8	28	95.9	1.224	1.518	0.518	0.238
Electric machinery and apparatus	872	37.8	471	88.4	1.000	1.246	0.750	0.535
Communication equipment and related products	150	35.0	94	76.7	2.120	2.498	0.689	0.318
Medical, precision and optical instruments	342	54.8	319	91.2	-1.577	-1.524	0.449	0.568
Motor vehicles	601	31.4	245	93.4	0.740	1.049	0.515	0.512
Other transportation equipments	144	34.1	147	87.2	1.478	1.702	0.467	0.423
Furnitures and other manufacturing	264	30.6	398	92.4	0.318	0.679	0.710	0.423

Notes: N is the number of firms, Ω is the export participation rate, P is the industry average productivity gap, P_X is the productivity gap of exporters, and σ is the standard deviation of firm productivity. Sources: Authors' own calculations based on firm-level data for France and Japan. For the details of the firm-level data, see the main text.

Table 2: Baseline Results: WLP

	(1)	(2)	(3)
	P_X	P_X	P_X
P	1.059***	1.201***	1.173***
	(0.009)	(0.085)	(0.066)
σ_{JP}	0.446***	0.380**	0.373***
	(0.080)	(0.168)	(0.120)
σ_{FR}	-0.221***	-0.386***	-0.291***
	(0.063)	(0.127)	(0.094)
Constant	0.088**	0.150	-0.003
	(0.040)	(0.089)	(0.005)
N	216	216	198
R-squared	0.995		0.775
R-squared (within)		0.894	
Estimation method	OLS	Fixed effect	First-difference
Year fixed effect	Yes	Yes	No
Number of industries	18	18	18

Notes: P_X is the productivity gap of exporters, P is the industry average productivity gap, and σ is the standard deviation of firm productivity. Productivity is estimated by the WLP method. Robust standard errors are in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. For the sources, see Table 1.

Table 3: Alternative Productivity Measures

	WLP		BB (System GMM)		GNS (Index)	
Industry	P	P_X	P	P_X	P	P_X
All manufacturing	0.169	0.369	0.071	0.112	0.694	0.985
Textile	0.660	0.763	0.721	0.777	0.894	1.126
Clothing	0.783	0.945	0.624	0.726	1.127	1.330
Manufacture of wood	-4.017	-4.151	-0.412	-0.385	-3.948	-4.133
Pulp and paper	1.413	1.872	0.178	0.215	2.298	2.862
Printing and publishing	-1.108	-1.069	-0.046	-0.011	1.110	1.500
Chemical products	0.319	0.506	-0.287	-0.264	0.988	1.305
Rubber and plastic	-1.453	-1.213	-1.085	-1.055	0.264	0.683
Non-metallic mineral products	0.451	0.778	-0.544	-0.500	1.121	1.625
Basic metal products	1.013	1.164	0.077	0.102	0.821	1.021
Fabricated metal products	-0.536	-0.455	-0.086	-0.066	0.239	0.411
Machinery and equipments	0.219	0.328	-0.044	-0.018	0.070	0.216
Machinery for office and services	1.224	1.518	0.466	0.531	-0.749	-0.414
Electric machinery and apparatus	1.000	1.246	0.330	0.368	0.462	0.674
Communication equipment and related products	2.120	2.498	0.153	0.203	2.475	2.902
Medical, precision and optical instruments	-1.577	-1.524	0.319	0.343	0.017	0.098
Motor vehicles	0.740	1.049	0.634	0.664	2.179	2.635
Other transportation equipments	1.478	1.702	0.558	0.598	2.835	3.238
Furnitures and other manufacturing	0.318	0.679	-0.274	-0.218	0.288	0.656

Notes:P is the industry average productivity gap; P_X is the productivity gap of exporters. Productivity is estimated by the WLP, BB (system GMM), and GNS (index) methods. For the sources, see Table 1.

Table 4: Regression Results: BB Method (System GMM)

	(1)	(2)	(3)
	P_X	P_X	P_X
P	1.075***	1.226***	1.142***
	(0.008)	(0.061)	(0.054)
σ_{JP}	0.532***	0.490**	0.457***
	(0.088)	(0.175)	(0.136)
σ_{FR}	-0.248**	-0.423***	-0.296***
	(0.122)	(0.129)	(0.095)
Constant	0.053	0.044	-0.004
	(0.047)	(0.079)	(0.005)
N	216	216	198
R-squared	0.995		0.783
R-squared (within)		0.906	
Estimation method	OLS	Fixed effect	First-difference
Year fixed effect	Yes	Yes	No
Number of industries	18	18	18

Notes: P_X is the productivity gap of exporters, P is the industry average productivity gap, and σ is the standard deviation of firm productivity. Productivity is estimated by the BB (system GMM) method. Robust standard errors are in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. For sources, see Table 1.

Table 5: Regression Results: GNS Method (Index Method)

	(1)	(2)	(3)
	P_X	P_X	P_X
P	1.009***	1.113***	1.029***
	(0.003)	(0.050)	(0.033)
σ_{JP}	0.539***	0.592***	0.420***
	(0.062)	(0.118)	(0.097)
σ_{FR}	-0.122***	-0.058*	-0.167***
	(0.031)	(0.031)	(0.031)
Constant	-0.003	-0.028	-0.001
	(0.008)	(0.018)	(0.001)
N	216	216	198
R-squared	0.998		0.830
R-squared (within)		0.906	
Estimation method	OLS	Fixed effect	First-difference
Year fixed effect	Yes	Yes	No
Number of industries	18	18	18

Notes: P_X is the productivity gap of exporters, P is the industry average productivity gap, and σ is the standard deviation of firm productivity. Productivity is estimated by GNS (index) method. Robust standard errors are in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. For the sources, see Table 1.

Table 6: Regression Results: Gap in the Export Productivity Premia

	WLP			BB (System GMM)			GNS (Index)		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
	P_E	P_E	P_E	P_E	P_E	P_E	P_E	P_E	P_E
σ_{JP}	0.746***	0.346*	0.282*	0.958***	0.419**	0.384**	0.589***	0.630***	0.403***
	(0.069)	(0.192)	(0.147)	(0.096)	(0.199)	(0.165)	(0.065)	(0.141)	(0.100)
σ_{FR}	-0.394***	-0.293**	-0.183*	-0.253**	-0.261**	-0.194**	-0.102***	-0.088***	-0.160***
	(0.063)	(0.106)	(0.093)	(0.127)	(0.093)	(0.083)	(0.033)	(0.030)	(0.030)
Constant	0.021	0.179*	-0.004	-0.150**	0.184	-0.005	-0.011	-0.018	-0.001
	(0.043)	(0.099)	(0.005)	(0.064)	(0.110)	(0.005)	(0.008)	(0.017)	(0.001)
N	216	216	198	216	216	198	216	216	198
R-squared	0.350		0.074	0.386		0.095	0.381		0.186
R-squared (within)		0.136			0.146			0.271	
Estimation method	OLS	Fixed effect	First-difference	OLS	Fixed effect	First-difference	OLS	Fixed effect	First-difference
Year fixed effect	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No
Number of industries	18	18	18	18	18	18	18	18	18

Notes: P_E is the gap in the export productivity premia; σ is the standard deviation of firm productivity. Productivity is estimated by the WLP, BB (system GMM), and GNS (index) methods. Robust standard errors are in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively. Year fixed effect is included. For the sources, see Table 1.

Table 7: Productivity of Exporters: Cross-country Comparison

	P	Ω	$\mu^X - \mu^N$	P_X
United States	0.000	0.180	0.020	0.000
France	-0.110	0.748	0.014	-0.124
United Kingdom	-0.117	0.695	0.097	-0.102
Japan	-0.150	0.275	0.056	-0.122
	P	Ω'	$\mu^X - \mu^N$	P_X
United States	0.000	0.108	0.020	0.000
France	-0.110	0.358	0.014	-0.120
United Kingdom	-0.117	0.351	0.097	-0.067
Japan	-0.150	0.120	0.056	-0.114

Notes: P is the industry average productivity gap relative to the United States, with a base year of 2005; Ω in the upper panel is the export participation rate; P_E^w is the export productivity premia; and P_X is the productivity gap of exporters. Ω' in the lower panel is the ratio of exports to gross output. Exports and gross output are manufacturing total in 2005.

Sources: P is obtained from Ministry of Economy, Trade and Industry (METI) (2013, Table I-1-3-2); Ω, from Bernard et al. (2007a, Table 2) for the United States, from (International Study Group on Exports and Productivity (ISGEP), 2008, Table 2) for France and the United Kingdom, and from Bellone et al. (2014, Table 3) for Japan. P_E^w is obtained from Bernard et al. (2007a, Table 3) for the United States, from Bellone et al. (2014, Table 4) for France and Japan, and from Greenaway and Kneller (2004, Table 1) for the United Kingdom. Exports and gross output are obtained from the World Input–Output Database (Timmer, 2012).

Figure 1: Productivity Gap as a Function of Export Threshold Value, dashed line = Country 1, solid line = Country 2