Globalisation and Regional Productivity Convergence: A Firm-level Analysis from India

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Abstract

This paper studies regional and national productivity convergence among manufacturing firms in India, using a panel data for the period 1998 to 2009. We find that firms that are further behind the productivity frontier grow faster and show more rapid convergence. The results also indicate that firms converge much quicker to their national frontiers than to their regional frontiers. We pay attention to the effects of globalization on the speed of convergence, and the results show that globalization facilitates firms' productivity growth but slows down the speed of convergence.

1. Introduction

In the macroeconomic literature of economic growth, productivity convergence is a process in which poor economies tend to grow faster and converge to rich economies, because of technological diffusion from the leaders to the followers (Barro and Sala-i-Martin 1992; Barro and Sala-i-Martin 1997). Much existing literature investigates cross-country productivity convergence and finds mixed results. For example, Bernard and Jones (1996) find little evidence of productivity convergence in the manufacturing sectors of 14 OECD countries, while Lee (2009) shows significant convergence in manufacturing. However, as emphasized by Pascual and Westermann (2002), it is important to compare industries which use similar technologies when analysing productivity convergence. Therefore, investigating productivity convergence at the disaggregated level is more informative. In addition, it should be noted that firms are the basic units of a country and the transfer of technology is mainly through activities among firms.

Despite of this importance, there has been little empirical work examining productivity convergence among firms. For these few studies at the firm level, most focus on how firms converge to their national frontier (Nishimura et al., 2005; Girma & Kneller, 2005; Chevalier et al., 2012), while the issue of productivity convergence to regional frontier has tended to be ignored. Regional productivity convergence is important because firms located in the same region share many common local characteristics, such as language, culture, and nature resource, etc., which might

facilitate productivity convergence. Given this, it is expected that the speed of convergence is faster to regional frontier than to national frontier. On the other hand, the distance to national frontier is general larger than to regional frontier, which provides more scope for convergence, and the regional frontier is not advanced enough for firms to converge, in this case, the convergence speed to the national frontier should be much higher. Which effect dominates is a question to be explored.

This paper fills a gap by studying the productivity of lagging (non-frontier) firms converge to both the national frontier and the regional frontier. We pay particular attention to the role of globalization, which is measured by export and outward foreign direct investment (OFDI). Specifically, we conjecture that globalization probably help improve firms' productivity growth rate but slow down the speed of convergence, because the globalization activities are largely confined to the most productive firms, the positive effects of globalization may have bigger impact on these most productive firms.

We study both national and regional productivity convergence in India, using a firm level manufacturing panel data in 14 Indian regions (13 states and 1 territory) from 1998 and 2009[1]. Our analysis extends the literature in two dimensions. First, we study how firms converge to the regional frontier and national frontier while previous firm-level studies mainly investigate how firms converge to the national frontier.

[1] In India, a financial year is from April 1st to March 31st next year. Wherever we refer to a calendar year in this study, it actually represents the corresponding financial year. For instance, a reference to 1998 would indicate the financial year starting in April 1998 and ending in March 1999.

Second, we study the effects of globalization on productivity convergence, paying particular attention to the role export and OFDI, which is important in India since Indian firms are quite active in export and investment abroad.

Based on the macroeconomic literature of economic growth, we employ a framework of productivity convergence proposed by Bernard and Jones (1996) and Cameron et al. (2005), which has been widely used in studying productivity convergence. We use Total Factor Productivity (TFP) as a measure of productivity.

The results of this paper show that firms converge both to their national frontier and regional frontier, and those further behind the frontier grow faster during our study period. We also find that firms converge faster to their national frontiers than to their regional frontiers. We test the effects of globalization on productivity growth and convergence and find that globalisation facilitates firms' productivity growth but slows down the speed of convergence.

The structure of this paper is as follows. Section 2 presents a brief review of existing literature. Section 3 discusses the methodology. Section 4 describes the dataset. Section 5 analyses the results and section 6 concludes.

2. Literature Review

2.1 Productivity convergence to the national frontier

The existing literature finds firm level evidence of productivity convergence, and most of these works study firms converging to their national frontiers (Nishimura et al., 2005; Girma and Kneller, 2005; Peri and Urban, 2006; Álvarez and Crespi, 2007; Chevalier et al., 2012). For instance, Nishimura et al. (2005) find strong evidence of productivity convergence among firms in most industries in Japan. Girma and Kneller (2005) show firm-level productivity convergence in UK service sector. Álvarez and Crespi (2007) find productivity catching-up in Chilean manufacturing.

Some researches compare productivity convergence to the global frontier and to the national frontier. Bartelsman et al. (2008) explore the productivity convergence process of UK firms to the global frontier and to the national frontier, and find that the national frontier exerts a stronger pull on domestic firms than the global frontier. Iacovone and Crespi (2010) evaluate the process of convergence towards national versus global frontier among plants in Mexico. The results show that plants converge much faster to national frontier than to global frontier. This study also shows that exposure to trade allows firms to speed up convergence to national frontier but has little effect on convergence to global frontier. Both of these two works emphasize that firms lagged so far technologically that they cannot learn from the global frontier. Another reason might be that the global frontiers usually located far away from domestic firms so they generate very limited effects.

2.2 Productivity convergence to the regional frontier

There has been not much work on regional productivity convergence among firms. To the best of our knowledge, the only paper that has examined firms' productivity convergence to the regional frontier is Griffith et al. (2009). This paper examines establishment level productivity convergence to both the national and regional frontiers in UK. The results show that establishments further behind the industry frontier experience faster growth rate, and converge to both the national and regional frontiers. The convergence speed is faster to the regional frontier than to national frontier, because knowledge spillovers may be to some extent geographically concentrated, so firms benefit more from frontiers that are located nearby, as explained by the authors. However, the main focus of this paper is examining convergence to the national frontier, and we are interested in convergence to both the national and regional frontier.

2.3 The impact of globalization

With the increasing trade liberalization in many countries, the impact of globalization on productivity growth has drawn growing attention in the literature. Many studies found that globalization enhances firms' productivity growth. For example, De Loecker (2007) uses micro data of Slovenian manufacturing firms and finds that firms become more productive once they start exporting. Van Biesebroeck (2005) finds similar results among sub-Saharan African manufacturing firms. Potterie and Lichtenberg (2001) show evidence that outward FDI is effective in the international diffusion of technology. Amiti and Konings (2007) show that with the reducing tariffs

on intermediate inputs, the cheaper imported inputs can raise productivity via learning, variety and quality effects. Khandelwal and Topalova (2011) examine the effect of India's trade reforms on firm productivity in the manufacturing sector, and the results indicate that the lower tariffs on the intermediate inputs generated a significant productivity boost.

However, little work paid attention to the effect of globalization on the speed of convergence at firm level. Chevalier (2012) explores the effect of globalization on productivity convergence process amongst firms. This study examines the effect of globalization (measured by exports) and information and communication technologies (ICT) on productivity convergence of French firms during 1991-2004, and finds that the speed of convergence decreased since 1992. The results show a positive relationship between export and productivity growth, and the authors explain that since exporters usually have the highest productivity and are the frontiers, the positive effect of export has bigger impact on those most productive firms and slow down the convergence process. Lancheros (2012) studies the effects of technology investments and international activities on innovation and technological convergence among Indian manufacturing and service firms, and find that exporting intensity increases the rate of innovation amongst Indian multinational firms, but slows down their speed of technological convergence.

In summary, the exiting literature indicates that firms are converging to the

technological frontiers with those further behind firms growing faster. But the issue of whether firms converge faster to their national frontier or to their regional frontier is still a question to explore. The literature also shows that globalization facilitates firms' productivity growth rate, while its effects on the speed of convergence is not known yet, especially for a developing country like India.

3. Empirical Framework

3.1 The baseline model

Our main interest lies in investigating firm level productivity convergence towards both the national and regional frontier and examining the role of globalisation in this process. We employ a formulation from the macroeconomic literature of productivity growth and convergence (see Bernard and Jones 1996 and Cameron et al. 2005), which has been extensively used in analysing cross-country productivity convergence. The model has also been widely employed in recent firm level productivity convergence studies (Nishimura et al., 2005; Griffith et al., 2009). This approach allows us to capture productivity convergence, productivity persistence over time and heterogeneity in productivity levels across firms. Equation (1) describes the starting point:

$$\ln A_{i,t} = \gamma_i + \lambda\left(\ln A_{F,t-1} - \ln A_{i,t-1}\right) + \ln A_{i,t-1} + \ln \epsilon_{i,t} \qquad (1)$$

Where $\ln A_{i,t}$ is the logarithm of firm i's productivity level in year t, the term ($\ln A_{F,t-1}$-$\ln A_{i,t-1}$) is a catch-up variable, which represents the distance between productivity

frontier F and firm i. Persistence is captured by firm's prior productivity level $\ln A_{i,t-1}$. The parameter γ_i reflect heterogeneity of productivity growth of firm i, and λ captures the speed of convergence. Finally, $\ln\epsilon_{i,t}$ represents the error term.

Re-arranging equation (1), taking the third term on the right-hand side over to the left-hand side, we obtain:

$$\Delta \ln A_{i,t} = \gamma_i + \lambda\left(\ln A_{F,t-1} - \ln A_{i,t-1}\right) + \ln\epsilon_{i,t} \qquad (2)$$

This provides our baseline specification. We will use this model to study how firms converge to their national frontiers, regional frontiers and compare the convergence speed to both frontiers. To be specific, if $\lambda > 0$, it means firms are converging to their frontiers, otherwise, it shows divergence.

3.2 The effects of globalization on productivity convergence

We extend our baseline model to test the effects of globalization on convergence. The globalization is measured by export and OFDI, which are denoted by the vector of $Z_{i,t}$. We add the globalization vector to capture the direct effect of globalization on rates of productivity growth, and an interaction term to capture its effect on the speed of productivity convergence. Then equation (2) becomes:

$$\Delta \ln A_{i,t} = \eta_i + \delta Z_{i,t-1} + \rho\left(\ln A_{F,t-1} - \ln A_{i,t-1}\right) + \mu Z_{i,t-1}\left(\ln A_{F,t-1} - \ln A_{i,t-1}\right) + \ln\varepsilon_{i,t} \qquad (3)$$

Where if $\delta>0$, it means that globalization has a positive effort on firms productivity growth, and if $\delta<0$, it indicates that globalization probably exert a negative effect on firms' growth. For the interaction term, if $\mu>0$, it means that globalization facilitates firms converging to their productivity frontiers, otherwise, it means globalization may hinder firms' productivity convergence.

3.3 Empirical strategy

We estimate the specification in equation (2) and (3) for all non-frontier firms to examine productivity convergence and the effects of globalization on the speed of convergence, while there are a number of challenges in doing this. One is to find an accurate measure of productivity and we will adopt the Levinsohn and Petrin (2003) approach to estimate and calculate firms' TFP to proxy to productivity.

Another issue is that we can only estimate the equations on surviving firms. Some firms may exit the market, and the exit decision is quite likely to be correlated with firms' productivity level (Fariñas and Ruano, 2005; Nishimura et al., 2005). This may produce sample selection bias. To address this problem, we follow Griffith et al. (2009) using a standard Heckman (1976) selection correction, that is to estimate a probit regression for firm survival and calculate the inverse Mills ratios using the estimation results, then include the inverse Mills ratios as an independent variables in the estimation equations. We model a firm's exit decision as a function of productivity,

firm size, age, capital stock, technology investment, the ratio of debt and equity, inward foreign investment, outward foreign investment, and export.

Since $\ln A_{i,t-1}$ appears on both sides of the regression equations, shocks such as measurement errors to $\ln A_{i,t-1}$ could lead to biased estimation of the convergence speed. The method of ordinary least squares (OLS) tends to underestimate the convergence speed as it produces a negative correlation between the gaps and the error term. The fixed effect faces the problem of overestimating the convergence speed. A solution is to find proper instruments which are not readily available in our dataset. Given these problems, we estimate our baseline model using the OLS and fixed effect and bear in mind that OLS has a downward bias and fixed effect has a upward bias.

4. Data and Measurement Issues

4.1 Data

Our main data source is from the Prowess database, which is compiled by the Centre for Monitoring the Indian Economy (CMIE). It collects annual financial statements for both listed and unlisted firms and is one of the most comprehensive firm-level database in India. The firms covered by this database account for more than 70% of industrial output, 75% of corporate taxes and more than 95% of excise taxes collected by the government. It includes firms from a wide cross-section of industries in

manufacturing, services and financial sectors. In this study, we concentrate on the manufacturing firms from 1998 to 2009.

It is worthwhile to mention that India includes 28[2] states and 7 union territories. Of these states, 14[3] are traditionally regarded as major states based on their Gross State Domestic Product, population and geographical size. These 14 states contribute about 70% of India's GDP and 87% of its population, which means results of these major states would be representative of the Indian economy (Shingal 2010). In addition, the non-major states have very few observations to conduct empirical analysis. Hence, we will focus our attention on major states and drop the non-major states except Goa which is small in size and close to Maharashtra, so we treat it as part of Maharashtra. We also drop Bihar since it is a service-oriented state. The union territories are usually cities, we treat them as part of the states that they are located in or close by[4] except Delhi, which is kept since it is National Capital Territory and relatively big and important. Thus, we concentrate our study on 13 major states and Delhi, as listed in table 1.

Then we are left with an unbalanced panel dataset including 8015 manufacturing firms of 12 years from 1998 to 2009. Our dataset comprises 14 two-digit

[2] Telangana was separated from Andhra Pradesh in June 2014, so India has 29 states now. But as our study period is 1998-2009, we treat Telangana as part of Andhra Pradesh.

[3] The 14 major states in India are Andhra Pradesh, Bihar, Gujarat, Haryana, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal.

[4] To be specific, we took "Chandigarh" as part of Punjab, "Dadra and Nagar Haveli" and "Daman and Diu" to Gujarat, "Pondicherry" to Tamil Nadu; "Andaman and Nicobar" and "Lakshadweep" are small islands with no data and were ignored in this study.

manufacturing industries. All data are deflated by wholesale price index based on financial year 1993-1994. To construct our total factor productivity (TFP) variable, we calculate the firm capital stock variable by adding the amount of land, plant, transport and furniture together; The intermediate inputs variable is calculated by aggregating the amount of raw materials, power and import of services; And the value added variable equals sales minus intermediate inputs. As most firms did not report data on employees in Prowess, we use wage as a proxy for the employees, and we test the validity of using wage in the appendix. We delete the upper and lower 0.1% of the observations according to TFP to control for outliers and this left us with an unbalanced panel of 48989 firm-year observations.

4.2 The productivity frontier

The distance to the frontier is one of the key elements in our study. We begin by defining the national productivity frontier as the firm with the highest level of TFP at the country level, and the regional frontier as the firm with the highest level of TFP of the state. The frontiers are defined for each individual industry and year. This approach allows for endogenous changes in the frontier over the period, as one firm may catch up and overtake the initial frontier next year.

This measure is not without problem. As the national frontiers are part of the regional frontiers, when a state's regional frontier is also the national frontier, firms' national gaps are equal to their regional gaps in that state. This would lead to lose efficiency

when we conduct empirical estimates to compare the national convergence and regional convergence by including both national gap and regional gap in equation (2). Another issue is the potential measurement error on TFP. To address these problems, as an robustness test, we define the national productivity frontiers as a weighted average of the top five firms with the highest levels of TFP in each industry and year, and the regional frontier as a weighted average of the top five highest TFP firms in the state in each industry and year.

4.3 Descriptive analysis

4.3.1 Productivity growth rate and productivity gap

Table 2 reports summary statistics of our main measures and table 3 shows the characteristic of our sample by states. $\triangle \ln TFP_{ijt}$ refers to the average TFP growth rate of firms that are never being frontiers during the study period, and "$\triangle \ln TFP_{Fjt}$" denotes to the average TFP growth rate of firms that at least once they are a regional frontier during the study period and "$\triangle \ln TFP_{Ft}$" the average TFP growth rate of firms that once being a national frontier. From table 1 we can find that the average TFP growth rate of non-frontier firms and regional frontier firms are very close, -0.51% and -0.44% per annum respectively. Similar pattern can also be found between non-frontier firms and regional frontier firms for many states in table 3. Some states show a bit higher average growth rate of non-frontiers than that of regional frontier firms, such as Andhra Pradesh, Gujarat, Karnataka, Maharashtra and so on. The average TFP growth rate of national frontier firms is much less than that of the

regional frontiers and non-frontiers. The negative average growth rates may largely be driven by some firms report negative average TFP growth rate. The average log gap between national frontiers and laggards is much higher than that between regional frontiers and laggards (3.58 versus 2.38), providing larger scope for firms catching up to national frontiers. For some states, the difference between average national gap and state gap is large, such as Karnataka, Kerala, Orissa, Rajasthan and Uttar Pradesh. While some other states show much small difference between the two gaps, such as Maharashtra. The standard deviations show that there is substantial variation in the gaps among firms. Figure 1 examines the Kernel density distribution of logarithm TFP and TFP growth rate of the whole sample, showing that there is variation in TFP levels and growth rate.

4.3.2 Globalisation and productivity growth

One of our main interest in this study is to examine the effects of globalisation on productivity growth and convergence. We use export and OFDI to measure globalisation. In our dataset, some firms export almost every year, while some firms export very few years during our study period. In this study, we explore the effects of continuous export on firms' productivity growth and convergence. Therefore, we define continuous export or permanent exporters in our dataset according to the following criteria:

a) firms that stay in the market for at least 3 years during our study period and export every year;

b) firms that exported continuously from the year they started exporting, at least 4 years;

c) firms that export for most of the period, and the criterion is the ratio of the years that export to the total years that firms in the market (at least 4 years) during the study period is higher than 0.6.

And the rest of the exporters are temporary exporters. As the temporary exporters export very few years, in this study, and we treat temporary exporters as non-exporters. Henceforth, we refer to exporters as permanent exporters, and non-exporters as temporary exporters and non-exporters. Of the 8015 manufacturing firms in our data, 2905 are exporters and 5110 are non-exporters.

Indian firms have recently gone a step further in their globalization process by undertaking overseas investments. Of the exporters, around 18.07% firms in our sample have expanded their operations abroad via OFDI. Whether this new form of globalisation help the already international firms to grow and converge is of great interests to explore. We examine the growth rate and converging process of those exporters that conduct OFDI in this study.

Table 4 compares the logarithm TFP and TFP growth between exporters, non-exporters and OFDI firms, controlled by firm size. The size is measured by firms' total assets, deflated by wholesale price index based on financial year 1993-1994. We

define 4 size groups (namely, very small, small, medium and large) across all observations by industry, and each size group shares almost same number of observations. From table 4 we can find that exporters are on average more productive than non-exporters, and those exporters that engage in OFDI show higher productivity levels than exporters and non-exporters. This is consistent with the literature that Exporters have superior performances relative to non-exporters but only the most productive firms conduct OFDI. We can also find that the TFP growth rate of exporters is on average higher than that of non-exporters except firms in large size group, but the average growth rate of OFDI firms is slightly lower than exporters. It is also worth noting that, firms bigger in size exhibit relatively higher productivity levels, but smaller size firms on average grow faster than bigger size firms.

From the descriptive analysis, we find that firms engaged in globalisation are on average more productive than the non-globalisation firms. As firms can gain new knowledge and advanced technologies when entering into the foreign market, this allows them to improve productivity and grow faster. Therefore, we conjecture that globalisation may help facilitate firms' productivity growth but slow down the speed of convergence because the globalisation firms are more productive and have less gap to frontier or some of them are frontiers, the positive effect of globalisation have bigger impact on them than on their non-globalisation counterpart firms. We conduct empirical analysis in the next section and test our hypothesis.

5. Empirical Results

In this section we present our empirical results. First, we start by estimating the baseline model to test the relationship between TFP growth rate and the distance behind the productivity frontier, comparing the convergence process to both the national and regional frontier. We then extend our baseline model to test the effect of export and OFDI on firms' productivity convergence, followed by a number of robustness tests.

5.1 Productivity convergence

We start by examining the relationship between a firm's TFP growth rate and its distance to the national TFP frontier and regional frontier respectively, controlling for only year effects and industry fixed effects for the OLS and year effects for fixed effect. The results are shown in column (1) and (2) of Table 5. We see that the results from both OLS and fixed effect show positive and significant correlation between TFP growth rate and the distance to the national frontier as well as to the regional frontier, revealing evidence of convergence. Another feature is that the coefficient of the national gap is higher than that of the regional gap, indicating that firms converge faster to the national frontier than to the regional frontier. Then we regress on both national gap and regional gap, the result is showing in column (3). For both the OLS and fixed effect, the coefficient of national gap is higher than regional gap, proving that firms are converging faster to the national frontier than to the regional frontier. In the section 1, we discussed that firms located in the same region share similar

characters such as language, culture, regulations which might facilitate firms converge to the regional frontier; on the other hand, the distance to national frontier is general larger than to regional frontier, which provides more scope for convergence. The empirical results show that the latter effect dominates to the former effect.

In column (4), (5) and (6), we add size, which is measured as the logarithm of total assets, age and inverse Mills ratio, which is to correct for possible bias due to sample selection. The negative and significant coefficients of size indicate that small firms experience faster growth than their counterparts large firms. This is consistent with the idea that smaller firms are more dynamic than large firms and generally grow faster. The coefficients of age are also negative and significant, showing that young firms are growing faster than old firms.

The results of the OLS and fixed effect are highly consistent, except that the coefficients of TFP gap terms by fixed effect method is much higher than that by OLS, which proves that the results of OLS has a downward bias on the convergence speed. In the following sections, we will concentrate on the method of fixed effect.

5.2 The effect of globalization

As mentioned above, one of our main interests lies in examining the effect of globalization on firms' productivity convergence. To investigate this, we extend our basic model by including a globalization term to capture the direct effect of

globalization on productivity growth, and an interaction term with the gap to capture its effect on the speed of productivity convergence. We use export and OFDI to proxy to globalization.

The results are presented in Table 6. Column (1) and (2) show the effect of export on productivity growth and convergence to the national frontier and regional frontier respectively, controlling only for the year effects. The coefficients of the national gap and regional gap are positive and significant, which is in line with the results in the basic specification, showing the evidence of convergence. The coefficients of export is positive but not significant in column (1). But it exhibits a positive and significant effect in column (2) on the regional convergence, showing that export facilitate firms' growth. This is consistent with the literature that exporters gain new knowledge and expertise in the export markets, which allows them to improve their productivity level (De Loecker 2007). While the coefficients of both the interactive term of export and national gap and the interactive term of export and regional gap are negative and significant, indicating that export has a negative effect on convergence. An explanation is that exporters are generally the most productive firms, as shown in section 4.3.2, and the positive effects of export may have a bigger impact on these firms (Chevalier et al. 2012) and slow down the convergence process. In column (3) and (4), we add size, age and inverse Mills ratio. The coefficient of export is positive but not significant in column (3), but it is positive and significant in column (4), proving export facilitate growth. The interactive terms of gap and export are still

negative and significant, implying that export hinder convergence. The negative and significant coefficients of size and age demonstrate that smaller and younger firms grow faster than bigger and older firms.

As discussed above, Indian firms have recently gone a step further in their globalization process by undertaking overseas investments. Most firms that conduct OFDI are exporters. In our sample, 90.52% firms that conduct OFDI are exporters. It is meaningful to test whether OFDI help the already exporters to grow and catch up.

Column (5) – (8) of Table 6 show the results of the effect of OFDI on productivity convergence among the exporters. In column (5) and (6), we control only for the year effects, and column (7) and (8) control for size, age, inverse Mills ratio and year effect. The coefficients of OFDI are positive but not significant in column (5) and (6) and become positive and significant when controlling for size, age and inverse Mills ratio in column (7) and (8), indicating that OFDI help improve firms' productivity growth. The coefficients of the interactive terms of OFDI and gap (both national gap and regional gap) are negative and significant in column (7) and (8), exhibiting that OFDI slow down convergence, as OFDI are generally confined in most productive firms and the positive effects of OFDI exert bigger impact on those most productive firms.

5.3 Robustness tests

We present a number of robustness tests to address potential data and econometric concerns. First, we use an alternative measure of distance behind the frontier by employing the weighted average logarithm TFP in the top five firms with the highest TFP levels as the frontiers to address potential measurement errors in frontiers. Then we impute employees to calculate TFP and test the robustness of our empirical results.

5.3.1 Measurement error

To address the potential measurement errors in productivity frontiers, we use the weighted average logarithm TFP in the top five firms with the highest TFP levels as the frontiers. That is we take the weighted average logarithm TFP of top five highest productive firms in each year and industry as the national frontier, and the weighted average logarithm TFP of top five highest productive firms in each state, year and industry as the regional frontier. The empirical results are shown in table 7. Column (1) – (3) are the basic results, controlling for size, age and inverse Mills ratio. Column (1) and (2) examine convergence to national frontier and regional frontier respectively, and column (3) compares national convergence and regional convergence in one equation. The results show that firms are converging to both their national frontiers and regional frontiers, and the higher coefficients of national gap reveals that firms converge faster to their national frontiers than to the regional frontiers, confirming our previous basic results in Table 5. Column (4) and (5) test the effect of export on productivity growth and convergence, and column (6) and (7) examine the effect of OFDI on growth and convergence among exporters. The positive and significant

coefficients of export and OFDI indicate that globalisation exert positive impact on firm productivity growth, while the negative and significant coefficients of the interactive terms of globalisation and gaps (except the interactive term of OFDI and state gap) show that globalisation slows down the convergence process. The results are highly consistent with our empirical results.

5.3.2 Imputed employees

We construct the employment data by running a regression in logs of the total number of employees (for those that are available) on the firm's total assets, controlling for year and industry, and use the predicted values for all other firms to impute the missing employment data. Then we use this imputed employment data to calculate TFP, and re-estimate our model to examine productivity convergence. The results are reported in Table 8.

Column (1) - (3) show the basic results of productivity convergence to the national frontier and regional frontier, controlling for size, age, inverse Mills ratio and year effects. Column (3) and (4) tests the effect of export on productivity convergence and column (5) and (6) show the effect of OFDI on convergence. The results are consistent with the previous results, showing that our former empirical analysis is robust.

6. Conclusion

In this paper we have studied the process of productivity convergence to both national frontiers and regional frontiers at the firm level, using a comprehensive micro manufacturing panel data in Indian 14 regions (13 states and 1 territory) from 1998 to 2009. Our results confirm the process of convergence among firms. The results show that firms are converging to both their national and regional frontiers. We compare the convergence speed to the national frontier and to the regional frontier, and find that firms converge quicker to their national frontier than to the regional frontier.

Since the trade liberalization in 1991, Indian firms has been quite active in globalisation activities. Exploring the role of globalisation on productivity growth and convergence is of great importance. We first examine the role of export on firms' catching up and growth and find that export facilitate productivity growth but slow down the convergence process. This is because exporters are more productive than non-exporters and they are closer to the frontiers and have less scope to converge or they are frontiers. Then we test whether OFDI further facilitate productivity growth for exporters and the results confirm this conjecture, showing that OFDI help improve the productivity growth but slow down convergence process.

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Table 1: List of states in this study

	name	type
1	Andhra Pradesh	major state
2	Gujarat	major state
3	Haryana	major state
4	Karnataka	major state
5	Kerala	major state
6	Madhya Pradesh	major state
7	Maharashtra	major state
8	Orissa	major state
9	Punjab	major state
10	Rajasthan	major state
11	Tamil Nadu	major state
12	Uttar Pradesh	major state
13	West Bengal	major state
14	Delhi	National Capital Territory

Table 2: Overall Descriptive Statistics

Variable		Mean	Std.Dev.
lnTFP	logarithm of TFP	1.6826	1.0189
$\triangle \ln TFP_{ijt}$	the TFP growth rate of non-frontiers	-0.0051	0.5639
$\triangle \ln TFP_{Fjt}$	the TFP growth rate of regional frontiers	-0.0044	0.6384
$\triangle \ln TFP_{Ft}$	the TFP growth rate of national frontiers	-0.0446	0.9915
lnGAP_NA	the distance behind the national frontier	3.5817	1.2365
lnGAP_state	the distance behind the regional frontier	2.3755	1.3075

Note: The sample includes 44173 observations in manufacturing over the period 1998-2009. The national frontier is the firm with the highest TFP level in an industry in a year, and the regional frontier is the firm with the highest TFP level in an industry in a year in the state. The term of "$\triangle \ln TFP_{ijt}$" refers to average TFP growth rate of firms that are always non-frontiers during the study period, and "$\triangle \ln TFP_{Fjt}$" denotes to the average TFP growth rate of firms that once they are a regional frontier during the study period and "$\triangle \ln TFP_{Ft}$" the average TFP growth rate of firms that once they are a national frontier during the study period. The term of "lnGAP_NA" ("lnGAP_state") is the average gap between national frontiers (regional frontiers) and laggards.

Source: Authors' calculations using the dataset.

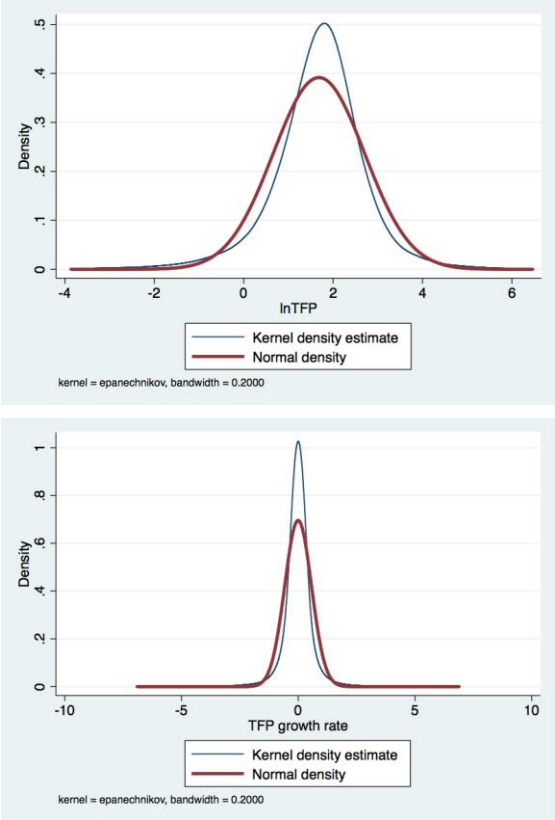
Table 3: Descriptive Statistics by State

statename	lnTFP	Std.Dev.	$\triangle lnTFP_{ijt}$	Std.Dev.	$\triangle lnTFP_{Fjt}$	Std.Dev.	lnGAP_NA	Std.Dev.	lnGAP_state	Std.Dev.
Andhra Pradesh	1.4876007	1.0699248	-0.0162553	0.65503256	-0.03927415	0.70720025	3.8453828	1.2447174	2.2405534	1.3573886
Gujarat	1.6852734	0.98686562	-0.00180863	0.55856856	-0.0030375	0.70984351	3.5997039	1.2063569	2.1657714	1.1752254
Haryana	1.6186568	1.0029667	-0.01096653	0.42984824	0.05542878	0.73909861	3.4952991	1.3647205	1.5102076	1.0428492
Karnataka	1.5748606	0.96823937	-0.01880093	0.54665206	-0.06097653	0.45407023	3.6640052	1.2180325	1.6776279	1.1384536
Kerala	1.355921	0.87787907	-0.00859345	0.65223337	0.04525505	0.58949491	3.8292449	1.1500958	1.367391	0.85473182
Madhya Pradesh	1.4569372	1.0622212	-0.00823127	0.63916281	-0.01664763	0.65935292	3.8479877	1.2152475	1.8888251	1.1919085
Maharashtra	1.8429007	1.0146676	-0.00353801	0.53533395	-0.02732809	0.81784235	3.4253771	1.2106198	3.0555211	1.2919073
Orissa	1.701059	1.0584357	-0.0522015	0.79144757	0.02612008	0.51032927	3.8038072	1.2410697	1.7487085	1.1307335
Punjab	1.5028559	0.91475751	-0.00648111	0.57087201	-0.01980528	0.67207631	3.7736495	1.1548342	1.8085495	1.0836602
Rajasthan	1.5007634	0.98677023	-0.01953756	0.55654233	0.02382936	0.55375633	3.8341672	1.1237294	1.5538561	1.0089207
Tamil Nadu	1.5537144	0.97420222	-0.00111421	0.54808983	-0.03091337	0.69567796	3.6506305	1.2493336	2.4246713	1.1647622
Uttar Pradesh	1.6793319	1.0796448	-0.01841018	0.56604531	0.04095486	0.43511068	3.6109383	1.2346695	1.6184473	1.1291679
West Bengal	1.7013741	1.0785935	0.0031425	0.6220063	-0.0334663	0.62342585	3.6642392	1.2447211	2.5135301	1.287401
Delhi	1.8279275	1.0038404	-0.00157274	0.53800431	0.00724068	0.62107122	3.3592566	1.2570771	2.2447259	1.144553

Note: The sample includes 44173 observations in manufacturing over the period 1998-2009. The national frontier is the firm with the highest TFP level in an industry in a year, and the regional frontier is the firm with the highest TFP level in the state in an industry and year. The term of "$\triangle lnTFP_{ijt}$" refers to average TFP growth rate of firms that are always non-frontiers during the study period, and "$\triangle lnTFP_{Fjt}$" denotes to the average TFP growth rate of firms that once they are a regional frontier during the study period. The term of "lnGAP_NA" ("lnGAP_state") is the average gap between national frontiers (regional frontiers) and laggards.

Source: Authors' calculations using the dataset.

Figure 1: Distribution of TFP and TFP growth



Note: The figures show the distribution of logarithm TFP and TFP growth rate of the whole sample respectively.

Table 4: Productivity Difference Across Size Groups

size	lnTFP				△lnTFP			
	all	exporters	non-exporters	OFDI	all	exporters	non-exporters	OFDI
Very small	1.17	1.372	1.113	1.619	0.00356	0.024	-0.00278	0.1
Small	1.601	1.693	1.532	1.758	0.00571	0.0209	-0.00654	-0.0127
Medium	1.837	1.888	1.752	1.998	-0.00841	-0.0073	-0.0105	-0.00842
Large	2.087	2.153	1.848	2.279	-0.0181	-0.0198	-0.0111	-0.0282
total	1.683	1.898	1.450	2.200	-0.00503	-0.00387	-0.00648	-0.02345

Note: The table compares logarithm TFP and TFP growth between exporters, non-exporters and OFDI firms. The exporters here refer to permanent exporting firms, and non-exporters including temporary exporting firms and non-exporters. The OFDI refers to those permanent exporting firms that also investing abroad. The size is measured by firms' total assets, deflated by wholesale price index. We define 4 size groups across all observations by industry, and each size group shares almost same number of observations.

Table 5: Productivity Convergence Basic Results

Dependent variable: TFP growth

	(1)	(2)	(3)	(4)	(5)	(6)
OLS						
$lnGAP\_NA_{it-1}$	0.1482***		0.1236***	0.1706***		0.1439***
	(0.003)		(0.004)	(0.003)		(0.004)
$lnGAP\_State_{it-1}$		0.1018***	0.0388***		0.1112***	0.0442***
		(0.003)	(0.003)		(0.003)	(0.003)
Size				-0.0054**	-0.0208***	-0.0061**
				(0.003)	(0.003)	(0.003)
Age				-0.0041***	-0.0039***	-0.0043***
				(0.000)	(0.000)	(0.000)
Inverse Mills ratio				-1.0271***	-0.9934***	-1.0790***
				(0.049)	(0.051)	(0.050)
_cons	-0.3172***	-0.0735*	-0.2529***	-0.2020***	0.4269***	-0.0062
	(0.030)	(0.040)	(0.040)	(0.035)	(0.042)	(0.043)
year dummies	yes	yes	yes	yes	yes	yes
industry dummies	yes	yes	yes	yes	yes	yes
N	34682	33470	33470	34657	33445	33445
Fixed effect						
$lnGAP\_NA_{it-1}$	0.3411***		0.2302***	0.3488***		0.2350***
	(0.004)		(0.006)	(0.004)		(0.006)
$lnGAP\_State_{it-1}$		0.3048***	0.1721***		0.3107***	0.1765***
		(0.004)	(0.005)		(0.004)	(0.005)
Size				-0.0238***	-0.0431***	-0.0217***
				(0.008)	(0.008)	(0.008)
Age				-0.0744***	-0.0689***	-0.0809***
				(0.003)	(0.003)	(0.003)
Inverse Mills ratio				-2.0873***	-2.0879***	-2.1642***
				(0.074)	(0.077)	(0.075)
_cons	-1.1812***	-0.6132***	-1.0447***	1.2402***	1.7668***	1.4301***
	(0.019)	(0.015)	(0.018)	(0.091)	(0.098)	(0.095)
year dummies	yes	yes	yes	yes	yes	yes
N	34682	33470	33470	34657	33445	33445

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors are displayed in parenthesis. The regressions are estimated on all non-frontier firms of manufacturing over the period of 1998-2009 in India, using OLS and fixed effect respectively. The dependent variable is the annual TFP growth rate. The national productivity frontier is defined as the firm with the highest TFP in the industry in a year, and the regional frontier is the firm with the highest TFP in an industry-year-state basis. The term "lnGAP_NA" denotes the distance to the national frontier while "lnGAP_State" the distance to the regional frontier. Size is defined as the logarithm of firms' total assets.

Table 6: Gloablisation and Productivity Convergence

Dependent variable: TFP growth

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$lnGAP\_NA_{it-1}$	0.3458***		0.3539***		0.2471***		0.2494***	
	(0.005)		(0.005)		(0.005)		(0.005)	
$lnGAP\_State_{it-1}$		0.3140***		0.3198***		0.2111***		0.2128***
		(0.005)		(0.005)		(0.005)		(0.005)
Export	0.0974	0.1474***	0.0632	0.1066**				
	(0.062)	(0.052)	(0.061)	(0.052)				
Export * lnGAP_NA	-0.0444***		-0.0464***					
	(0.014)		(0.014)					
Export * lnGAP_State		-0.0773***		-0.0755***				
		(0.015)		(0.015)				
OFDI					0.0192	0.0200	0.0387**	0.0429**
					(0.019)	(0.020)	(0.019)	(0.020)
OFDI * lnGAP_NA					-0.0132**		-0.0112**	
					(0.006)		(0.006)	
OFDI * lnGAP_State						-0.0218***		-0.0173**
						(0.008)		(0.008)
Size			-0.0208***	-0.0398***			-0.0571***	-0.0711***
			(0.008)	(0.008)			(0.009)	(0.009)
Age			-0.0744***	-0.0688***			-0.0498***	-0.0467***
			(0.003)	(0.003)			(0.003)	(0.003)
Inverse Mills ratio			-2.0947***	-2.0920***			-1.1710***	-1.2028***
			(0.074)	(0.077)			(0.082)	(0.085)
_cons	-1.1897***	-0.6296***	1.2195***	1.7379***	-0.8481***	-0.4059***	1.1026***	1.5099***

	(0.020)	(0.016)	(0.091)	(0.098)	(0.021)	(0.015)	(0.104)	(0.112)
year dummies	yes	yes	yes	yes	yes	yes	yes	yes
N	34682	33470	34657	33445	19221	18543	19213	18535

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors are displayed in parenthesis. The regressions are estimated on all non-frontier firms of manufacturing over the period of 1998-2009 in India using fixed effect. The dependent variable is the annual TFP growth rate. The national productivity frontier is defined as the firm with the highest TFP in the industry in a year, and the regional frontier is the firm with the highest TFP in an industry-year-state basis. The term "lnGAP_NA" denotes the distance to the national frontier while "lnGAP_State" the distance to the regional frontier. "Export" is the ratio of export and sales, and "OFDI" is a dummy variable equals 1 if a firm investments outside India in that year. Size is defined as the logarithm of firms' total assets.

Table 7: Productivity Convergence Robustness Tests

Dependent variable: TFP growth

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$lnGAP\_NA_{it-1}$	0.5159***		0.3034***	0.5226***		0.4135***	
	(0.005)		(0.009)	(0.005)		(0.006)	
$lnGAP\_State_{it-1}$		0.5022***	0.2614***		0.5208***		0.3784***
		(0.005)	(0.009)		(0.006)		(0.006)
Export				0.0876	0.1821***		
				(0.055)	(0.044)		
Export * lnGAP_NA				-0.0603***			
				(0.015)			
Export * lnGAP_State					-0.1431***		
					(0.016)		
OFDI						0.0336*	0.0295*
						(0.018)	(0.018)
OFDI * lnGAP_NA						-0.0141**	
						(0.007)	
OFDI * lnGAP_State							-0.0113
							(0.010)
Size	-0.0127*	-0.0148*	-0.0079	-0.0098	-0.0106	-0.0456***	-0.0515***
	(0.008)	(0.008)	(0.007)	(0.008)	(0.008)	(0.008)	(0.009)
Age	-0.0938***	-0.0895***	-0.0987***	-0.0937***	-0.0894***	-0.0709***	-0.0647***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Inverse Mills ratio	-2.1906***	-2.1848***	-2.2291***	-2.1978***	-2.1920***	-1.2326***	-1.2334***
	(0.070)	(0.072)	(0.070)	(0.071)	(0.072)	(0.079)	(0.080)
_cons	1.4949***	2.0779***	1.8060***	1.4696***	2.0315***	1.3809***	1.7993***
	(0.086)	(0.093)	(0.091)	(0.086)	(0.093)	(0.099)	(0.107)
year dummies	yes	yes	yes	yes	yes	yes	yes
N	34743	34126	34126	34743	34126	19268	18966

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors are displayed in parenthesis. The regressions are estimated on all non-frontier firms of manufacturing over the period of 1998-2009 in India using fixed effect. The dependent variable is the annual TFP growth rate. The national productivity frontier is defined as the weighted average logarithm TFP of the top five firms with highest levels of TFP in each industry and year, and the regional frontier is the weighted average logarithm TFP of the top five highest TFP firms in the state in each industry and year. The term "lnGAP_NA" denotes the distance to the national frontier while "lnGAP_State" the distance to the regional frontier. "Export" is the ratio of export and sales, and "OFDI" is a dummy variable equals 1 if a firm investments outside India in that year. Size is defined as the logarithm of firms' total assets.

Table 8: Productivity Convergence Robustness Tests

Dependent variable: TFP growth

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$lnGAP\_NA_{it-1}$	0.4671***		0.2831***	0.4792***		0.3710***	
	(0.005)		(0.007)	(0.005)		(0.006)	
$lnGAP\_State_{it-1}$		0.4496***	0.2439***		0.4590***		0.3480***
		(0.005)	(0.007)		(0.005)		(0.006)
Export				0.2383***	0.1163**		
				(0.057)	(0.048)		
Export * lnGAP_NA				-0.1082***			
				(0.017)			
Export * lnGAP_State					-0.0817***		
					(0.018)		
OFDI						0.0547***	0.0682***
						(0.018)	(0.018)
OFDI * lnGAP_NA						-0.0229***	
						(0.007)	
OFDI * lnGAP_State							-0.0394***
							(0.010)
Size	-0.0878***	-0.0846***	-0.0793***	-0.0856***	-0.0830***	-0.1057***	-0.1052***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Age	-0.0107***	-0.0191***	-0.0163***	-0.0114***	-0.0194***	0.0089***	0.0026
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Inverse Mills ratio	-2.4276***	-2.5319***	-2.5705***	-2.4455***	-2.5430***	-1.4354***	-1.4771***
	(0.071)	(0.074)	(0.072)	(0.071)	(0.074)	(0.077)	(0.080)
_cons	-0.0272	0.5420***	0.1004	-0.0451	0.5304***	-0.2963***	0.1613**
	(0.069)	(0.071)	(0.070)	(0.069)	(0.071)	(0.076)	(0.077)
year dummies	yes	yes	yes	yes	yes	yes	yes
N	36496	35248	35248	36496	35248	20320	19580

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors are displayed in parenthesis. The regressions are estimated on all non-frontier firms of manufacturing over the period of 1998-2009 in India using fixed effect. The TFP is calculated using imputed employees to test the robustness of the empirical results. The dependent variable is the annual TFP growth rate. The national productivity frontier is defined as the firm with the highest TFP in the industry in a year, and the regional frontier is the firm with the highest TFP in an industry-year-state basis. The term "lnGAP_NA" denotes the distance to the national frontier while "lnGAP_State" the distance to the regional frontier. "Export" is the ratio of export and sales, and "OFDI" is a dummy variable equals 1 if a firm investments outside India in that year. Size is defined as the logarithm of firms' total assets.

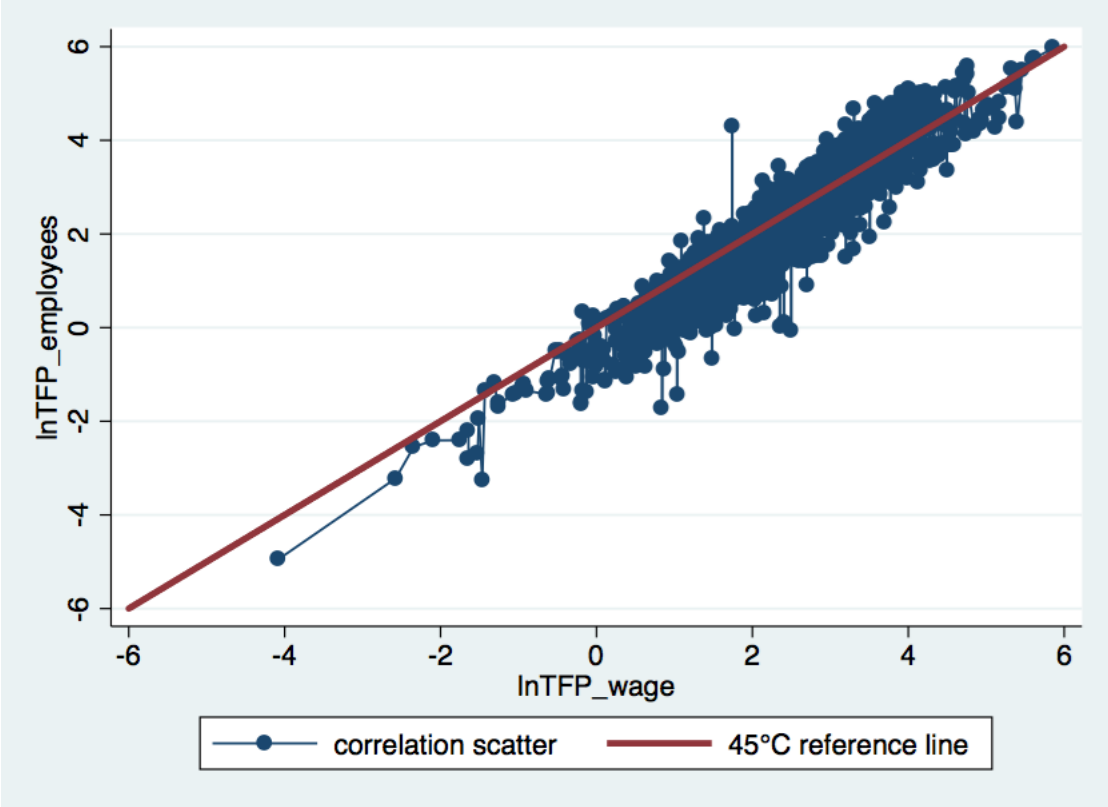
Appendix

A. Test the validity of using wage to calculate TFP

A problem of our dataset is that most firms' employment information is missing, only a small fraction of firms report employee numbers. Fortunately, most firms have the wage information. Therefore, we use wage as an instrument for the employee numbers in calculating TFP. To test whether it is valid to use wage to proxy to employee numbers, we calculate TFP for those observations that have both the employment data and wage, using employee numbers and wage as free input respectively, and then compare the results.

There are 4607 observations that have both the information of employee numbers and wage. We calculate TFP for this subsample. The correlation between those two TFPs is as high as 0.9382, implying that our method of using wage to compute TFP is valid. We also depict the relationship between these two TFP, which is shown in Figure 1. The y-axis indicates the TFP using employee numbers and the x-axis refers to the TFP using wage. The red thick line is a 45 degree reference line. From this graph we can see that the two TFPs are highly correlated. Therefore, it is safe to use wage as a proxy to employee numbers and calculate TFP in our sample, and our results are convincing.

Figure A1: Correlation between the two TFPs



Note: The figure shows the correlation between TFP calculated using employees and wage for the sub-sample (4,527 observations) that has both employees and wage information. The y-axis indicates the TFP using employee numbers and the x-axis refers to the TFP using wage. The thick line is a 45 degree reference line.