

Labor heterogeneity and total factor productivity: evidence from Vietnamese manufacturing private sector

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ABSTRACT

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This paper investigates firm heterogeneity in total factor productivity across Vietnam domestic private sector with sixteen manufacturing sub-industries over the period 2010-2016, with a focus on labor size and based on total factor productivity (TFP); including TFP level, TFP distance, and TFP dispersion. Our results indicate that, in the private sector, labor heterogeneity on productivity are very dependent on specific manufacturing sectors, and on type of TFP. From an industrial policy perspective, there is hence productivity related reason on why Vietnamese policy makers should prefer large and extremely large firms over small and medium enterprises (SMEs) in some manufacturing and vice versa. Our results provide a support for both SMEs and large private consortiums, depending on specific manufacturing sectors. In addition, since there is a strong evidence to suggest that labor heterogeneity in TFP exists in some manufacturing sectors, the rationality behind policies to support SMEs and large firms at every manufacturing sectors seems to be questionable.

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1. Introduction

Firm's productivity is determined by its characteristics, for example, as synthesized by Harris and Moffat (2015), internal and external knowledge, economies of scale and competition effects, and spillover effects. In this context, firm size plays a crucial role (Jovanovic, 1982; Pakes & Ericson, 1998). For example, large firms have an advantage over small firms since they can use market power and economies of scale (Jovanovic, 1982). Thus, heterogeneity in firm-specific factors determines firm heterogeneity in productivity. Several studies have found that firm size has positive effect on TFP (Van Biesebroeck, 2005; Jovanovic, 1982; Malerba, 1992) due to the experience of larger companies, popularly known as the learning-by doing effects. On the other hand, studies by Williamson (1967), and Utterback (1994) have concluded that small firms have higher productivity or efficiency due to their lean organizational structure. The empirical results thus are still mixed. Most recent study related to TFP in Vietnam by Nguyen (2017) examined TFP changes during business reforms in Vietnam from 2000 to 2010 and found that technology gap in terms of TFP differs between the least productive firms and the frontier firms and the differences are narrowed down across industries (and economic regions).

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Our paper contributes to the empirical literature in some aspects. First, for the first time, we look at the productivity through the lens of labor heterogeneity in Vietnamese manufacturing industry. Second, while most of the firm-level previous studies examine the concern issue at aggregate level of manufacturing, we, by exploring the enriched dataset, try to uncover the effects at disaggregate level of sixteen manufacturing sub-sectors. Third, in the current paper, we explore some additional measures of TFP, namely: TFP distance (which is measured as the TFP difference between a firm and the highest-TFP firm and the top-3 TFP firms) and TFP dispersion (which is measured as the difference in TFP between a firm and the sector as a whole). Our study is differentiated from Nguyen (2017) in some neglected aspects: (1) we focus on labor heterogeneity in TFP, (2) we employ of the most recently updated seven-year dataset, and (3) we analyze TFP at disaggregated level of sixteen manufacturing sub-sector.

The remainder of this article is organized as follows: In Section 2 on “Study Design”, the data source, and TFP estimation are discussed. Section 3, “Labor Heterogeneity and TFP”, presents statistical analysis of the correlation between labor size and some measures of TFP. Finally, Section 4 is “Conclusions and Implication”.

2. Study design

2.1. Data source

The main data source for production function estimation is the Vietnam Annual Enterprise Survey (VAES) which is conducted annually by General Statistical Office (GSO) of Vietnam. It is designed to provide annual data for financial performance and financial position by broad industry groups. The surveys collected information on firms’ activities, including numerous indicators such as firm characteristics, location, industries, labor and wages, assets and liabilities, export and import of goods, and business results (including: turnover, cost of goods, administration costs, net profit) at the firm level. All types of manufacturing sectors were covered in the sample. The classification of manufacturing sector is defined is based on VSIC 2007, which corresponds closely to the fourth revision of the International Standard Industrial Classification of All Economic Activities (ISIC4 Revision) (United Nations, 2008). Number of manufacturing sectors available for analysis are presented in Table 1.

Table 1

Cobb-Douglas production function estimation using Akerberg-Caves-Frazer estimator
(Dependent variable: Value added (logarithm), 2010-16)

VARIABLES	(1) sector 10	(2) sector 11	(3) sector 13	(4) sector 14	(5) sector 15	(6) sector 16	(7) sector 17	(8) sector 18
Capital (log)	0.517*** (0.0513)	0.800*** (0.145)	0.473*** (0.0192)	0.0341 (0.0227)	0.139*** (0.0362)	0.389*** (0.0349)	0.326*** (0.0493)	0.260*** (0.0596)
Labor (log)	0.712*** (0.0724)	0.605* (0.314)	0.755*** (0.0332)	1.105*** (0.0378)	0.931*** (0.0385)	0.901*** (0.0862)	1.041*** (0.109)	1.117*** (0.179)
Observations	4,865	485	2,010	4,445	1,525	1,820	1,770	970
Wald test statistic of constant returns to scale	85.48	5.162	152.7	50.19	24.73	23.71	30.35	8.442
Sargan-Hansen test statistic	4.19e-09	3.87e-08	6.84e-09	3.03e-08	2.89e-08	1.45e-09	1.78e-07	4.93e-08
<i>Continued</i>								
VARIABLES	(9) sector 20	(10) sector 22	(11) sector 23	(12) sector 24	(13) sector 25	(14) sector 27	(15) sector 28	(16) sector 31
Capital (log)	0.621*** (0.0328)	0.426*** (0.0448)	0.363*** (0.0659)	0.476*** (0.0138)	0.482*** (0.0429)	0.576*** (0.0478)	0.472*** (0.0662)	0.223*** (0.0680)
Labor (log)	0.597*** (0.0577)	0.789*** (0.0562)	0.986*** (0.111)	0.792*** (0.0215)	0.490*** (0.108)	0.620*** (0.0660)	0.707*** (0.206)	0.947*** (0.106)
Observations	1,825	2,765	3,770	620	3,360	1,040	810	2,445
Wald test statistic of constant returns to scale	51.99	107.8	52.50	219.6	0.0583	57.84	1.351	5.093
Sargan-Hansen test statistic	9.18e-09	6.12e-09	1.82e-08	7.00e-09	6.456	1.59e-08	2.28e-08	8.96e-08

Note: Z-test statistics are in parenthesis; Wald test of constant returns to scale; Proxy variables: raw material expenses. The underidentification test is based on the Kleibergen-Paap Lagrange multiplier statistic, the weak identification test is based on the Kleibergen-Paap Wald F statistic, the F-test is based on the Angrist-Pischke multivariate F-test of excluded instruments in the first stage, and the test for the overidentifying restrictions is based on Sargan-Hansen’s J-test.

Note: Industry codes are as follows: 10: Food products; 11: Beverages; 13: Textiles; 14: Wearing apparel; 15: Leather and related products; 16: Wood and products of wood/cork; 17: Paper and paper products; 18: Printing and reproduction of recorded media; 20: Chemicals and chemical products; 22: Rubber and plastics products; 23: Other non-metallic mineral products; 24: Basic metals; 25: Fabricated metal products; 27: Electrical equipment; 28: Machinery and equipment n.e.c; 31: Furniture.

Source: Authors’ estimation from VAES 2010-16

Private sector is defined on the basis of ownership and include the following entities: (1) private enterprise, (2) joint-stock company without state-owned capital, (3) private limited company with state-owned capital less than 50 percent.

In the current paper, firms with more than 5000 employees are classified as extreme-large firms, those with 1000–5000 employees as upper-large firms, those with 500–1000 employees as lower-large firms, those with 300–500 employees as big firms, those with 200–300 employees as upper-medium firms, those with 50–200 employees as lower-medium firms, those with 10–50 employees as small firms.

2.2 TFP estimation

2.2.1 Approach to estimate TFP

To accomplish the objectives of this study, our empirical analysis starts with the estimation of TFP. This is done separately for all sixteen sample industries. It is noteworthy that the use of ordinary least squares (OLS) in the estimation of the production function may lead to some serious problems. As pointed out by Griliches and Mairesse (1995), profit-maximizing firms immediately adjust their inputs (in particular capital) each time they observe a productivity shock, which ensures input levels are correlated with the same shocks. Since productivity shocks are unobserved, they enter in the error term of the regression. Hence, inputs may turn out to be correlated with the error term of the regression, and thus OLS estimates of production functions are biased. Olley and Pakes (1992) (OP, hereafter) and Levinsohn and Petrin (2003) (LP, hereafter) developed two similar semi-parametric estimation procedures to overcome this problem. As claimed by Akerberg et al. (2006), multicollinearity could happen when labor is correlated with the proxy, then the labor coefficient cannot be identified. To overcome this issue, Wooldridge (2009) and later Petrin and Levinsohn (2012) (LP) suggested applying IVs estimator using the own lags of labor for its instruments. (Akerberg et al., 2006) suggest a method that builds upon the ideas in OP and LP, e.g. using investment or intermediate inputs to “proxy” for productivity shocks, but does not suffer from the above collinearity problems. AFC procedure, however, unlike the OP and LP procedures, which estimate the labor coefficient in the first stage (where the collinearity issue arises), involves estimating the labor coefficient in the second stage.

In this study, we prefer the AFC methodology, which is an extension of the LP technique for computation of TFP. This methodology explicitly recognizes and overcomes the endogeneity, which occurs because at least a part of the TFP is observed by the profit maximizing firms early enough to allow the factor input decisions to be changed, and possible collinearity between labor and proxy variable. Specifically, we follow the value-added method of the AFC procedure and deflated gross value added (LY) of firms is used as a measure of output. Further, in this process intermediate inputs (raw material) are used as proxy, to avoid the biasness problem.

2.2.2 Other TFP measurements

TFP distance

Technological distance (technological difference): The gap in TFP is measured as the difference in TFP between a firm and the firm with the highest TFP and between a firm and the top-3 firms with high TFP.

$$\begin{aligned} TFPgap_1 &= \ln(TFP)_{top1} - \ln(TFP) \\ TFPgap_3 &= \ln(TFP)_{meanptop3} - \ln(TFP) \end{aligned}$$

where:

$\ln(TFP)_{top1}$: $\ln(TFP)$ of the firm with highest TFP

$\ln(TFP)_{meanptop3}$: Mean of $\ln(TFP)$ of top-3 firms

$\ln(TFP)$: $\ln(TFP)$ of a firm in consideration

As TFP is expressed in log values, the gap has interesting implication. It can be inverted to the ratio between the output produced by the TFP frontier and the output produced by the least productive, assumed that both using the same inputs (Syverson, 2010): $\text{Ratio} = e^{\text{TFPgap}}$

TFP dispersion

Technological diffusion (technological dispersion) is measured as the difference in TFP between a firm and the sector as a whole.

$$\text{TFPdiff}_i = \ln(\text{TFP}) - \ln(\text{TFP})_{\text{mean}}$$

where:

$\ln(\text{TFP})_{\text{mean}}$: Mean of $\ln(\text{TFP})$ of the manufacturing sub-sector

$\ln(\text{TFP})$: $\ln(\text{TFP})$ of a firm

2.2.3 Empirical results of TFP estimation

The estimated production function is reported in Table 1 for each sub-industry, which suggests that workers (logarithm of labor) and capital (logarithm of capital) are significant in all industries at 1 per cent level of significance.

Factor elasticities

We observe capital elasticities ranging from 0.03 to 0.81. Firms in food products, beverages, chemicals and chemical products, electrical equipment, motor vehicles, trailers and semi-trailers, and repair and installation of machinery and equipment have the highest capital coefficients, above 0.5. These sectors are among the smaller sectors in the sample when measured by total value added but yield the highest value-added returns to capital. Firms in wearing apparel have the lowest capital coefficient, below 0.1. Labor elasticities ranging from 0.36 to 1.4. Firms in all sectors, except for fabricated metal products, and repair and installation of machinery and equipment, have labor elasticities above 0.5. We do not find evidence of constant returns to scale in all sectors, whereas all of them are characterized by increasing returns to scale.

3. Labor heterogeneity and TFP

3.1 Labor heterogeneity in TFP level

Table 2 presents average levels of TFP for Vietnamese manufacturing private sector. The null hypothesis that TFP level differs statistically among heterogeneous labor groups is tested using analysis of variance (ANOVA). It should be noted that the stars on the first, second and third groups and so on from the top represent that the averages between the first and second, first and third, and second and third groups and so on are statistically different in pair-wise tests. In general, applying to the private sector, the tests show that significant labor heterogeneity in TFP exists for almost all of manufacturing sectors considered (some manufacturing sectors with small number observations are omitted from the analysis). Firm size in terms of labor indicates that SME firms have significantly different TFP from big and large ones, big firms are also significantly different from large ones in terms of TFP levels and lower-large firms are also significantly different from upper- and extreme-large ones in terms of TFP levels. TFP level increases as firm sizes change from a small firm to a medium firm, big firm and then to a large firm.

Column 2 in Table 2 presents the result in food products (code 10). We find also that labor heterogeneity exists, indicating that SME firms have significantly different TFP levels from big and large ones, big firms are also significantly different from large ones in terms of TFP levels and lower-large firms are also significantly different from upper- and extreme-large ones in terms of TFP levels. TFP level increases as firm sizes change from a small firm to a medium firm, big firm and then to a large firm. Similar results are found with other non-metallic mineral products (code 23).

Column 3 in Table 2 presents the result in beverages (code 11). We find that labor heterogeneity only happens between small and lower-medium firms. We find the evidence of labor heterogeneity between small, lower-medium firms and upper-medium and big firms with Fabricated metal products (code 25) in column 14. In column 4 of Table 2, we observe that labor heterogeneity occurs in Textiles sector (code 13) between small and big firms. Wearing apparel sector (code 14) in column 5 does not show any evidence of labor heterogeneity over the range of labor size. We find no similar evidence in Basic metals (code 24), Electrical equipment (code 27), Machinery and equipment not yet classified (n.e.c) (code 28), and Furniture (code 31). Leather and related products sector (code 15) in column 6 gives evidence of heterogeneity between small and lower-medium firms. The same is found with Wood and products of wood/cork (code 16), Paper and paper products (code 17), Printing and reproduction of recorded media (code 18), Chemicals and chemical products (code 20).

Table 2
Labor heterogeneity in TFP level: Vietnamese manufacturing domestic private sector (2010-16)

Firm size	(1) All sectors	(2) (Code 10)	(3) (Code 11)	(4) (Code 13)	(5) (Code 14)	(6) (Code 15)	(7) (Code 16)	(8) (Code 17)	(9) (Code 18)
Small	5.46 ^{a***, b***, c***, d***, e***, f***} (1.16) [3,753]	4.62 ^{a, b, c, d, e***} (0.74) [798]	2.71 ^{a**} (1.07) [62]	5.30 ^{a, b**, c} (0.73) [160]	7.94 ^{a, b, c, d, e} (0.67) [91]	9.67 ^{a***} (0.48) [74]	5.90 ^{**} (0.76) [315]	6.01 ^{a***} (0.64) [226]	6.53 ^{a***} (0.48) [143]
Lower-medium	5.63 ^{b, c, d***, e***, f***} (1.25) [4,989]	4.67 ^{b, c, d, e***} (0.71) [775]	3.07 (0.84) [96]	5.26 ^{b***, c} (0.72) [171]	8.01 ^{b, c, d, e} (0.85) [289]	10.61 (0.57) [119]	5.78 (0.71) [317]	5.72 (0.60) [284]	6.37 (0.48) [180]
Upper-medium	5.60 ^{c, d***, e***, f***} (1.41) [1,269]	4.53 ^{c, d, e***} (0.70) [231]		5.63 ^{c*} (0.65) [56]	8.03 ^{c, d, e} (0.74) [93]				
Big	5.74 ^{d, e***, f***} (1.56) [1,194]	4.69 ^{d, e***} (0.57) [253]		5.28 (0.49) [58]	7.88 ^{d, e} (0.73) [172]				
Lower-large	5.90 ^{e***, f***} (1.75) [858]	4.54 ^{e***} (0.60) [260]			7.96 ^e (0.57) [177]				
Upper-large	6.87 ^{f***} (2.41) [620]	4.24 (0.60) [178]			7.94 (0.52) [190]				
Extreme-large	8.35 (2.24) [50]								

<i>continued</i>								
Firm size	(10) (Code 20)	(11) (Code 22)	(12) (Code 23)	(13) (Code 24)	(14) (Code 25)	(15) (Code 27)	(16) (Code 28)	(17) (Code 31)
Small	4.46 ^{a***} (0.67) [217]	5.78 ^{a, b, c} (0.57) [148]	5.75 ^{a***, b***, c***, d***} (0.90) [559]	5.18 ^a (0.61) [67]	5.45 ^{a***, b***, c***} (0.67) [532]	4.76 ^a (0.48) [58]	5.25 ^a (0.58) [114]	6.90 ^{a, b, c, d} (0.61) [138]
Lower-medium	4.64 (0.63) [215]	5.75 ^{b, c} (0.69) [271]	5.54 ^{b***, c***, d***} (0.64) [1,311]	5.28 (0.52) [61]	5.93 ^{b*, c***} (0.58) [334]	4.70 (0.65) [130]	4.89 (0.59) [96]	7.02 ^{b**, c*, d} (0.71) [150]
Upper-medium		5.74 ^c (0.59) [63]	5.38 ^{c***, d***} (0.64) [297]		6.13 ^c (0.45) [72]			6.70 ^{c, d} (0.81) [71]
Big		5.74 (0.91) [60]	5.37 ^{d***} (0.66) [243]		6.23 (0.52) [66]			6.69 ^d (0.55) [52]
Lower-large			5.39 (0.56) [106]					6.86 (0.87) [70]

Note: Standard error in the parentheses, number of observations in the square brackets.

***, **, *: The averages are statistically different at the 1%, 5%, 10% level.

For multiple groups, the stars on 1st, 2nd and 3rd and so on groups from the top represent the averages between 1st and 2nd, 1st and 3rd, and 1st and 4th groups and so on are statistically different, respectively. For example: a, b, c, d, e, f in column (1) denotes the difference between small firms and lower-medium firms, upper-medium firms, big firms, lower-large firms, upper-large firms, and extreme-large firms, respectively. The signal a in column (3) denotes the difference between small firms and lower-medium firms only. Industry codes are as follows: 10: Food products; 11: Beverages; 13: Textiles; 14: Wearing apparel; 15: Leather and related products; 16: Wood and products of wood/cork; 17: Paper and paper products; 18: Printing and reproduction of recorded media; 20: Chemicals and chemical products; 22: Rubber and plastics products; 23: Other non-metallic mineral products; 24: Basic metals; 25: Fabricated metal products; 27: Electrical equipment; 28: Machinery and equipment n.e.c; 31: Furniture.

Source: Authors' estimation from VAES 2010-2016

3.2. Labor heterogeneity in TFP distance

Table 3 presents average level of TFP distance (TFP distance to the top 1 firm) for Vietnamese manufacturing private sector.

Table 3

Labor heterogeneity in TFP distance (compare to top 1): Vietnamese manufacturing domestic private sector (2010-16)

Firm size	(1) All sectors	(2) (Code 10)	(3) (Code 11)	(4) (Code 13)	(5) (Code 14)	(6) (Code 15)	(7) (Code 16)	(8) (Code 17)	(9) (Code 18)
Small	5.90 ^{a,***, b, c,***, d,***, e,***, f,***} (1.16) [3,753]	6.74 ^{a, b, c, d, e,***} (0.74) [798]	8.65 ^{a**} (1.07) [62]	6.06 ^{a, b,***, c} (0.73) [160]	3.42 ^{a, b, c, d, e} (0.67) [91]	1.70 ^{a***} (0.48) [74]	5.46 ^{a**} (0.76) [315]	5.35 ^{a**} (0.64) [226]	4.83 ^{a***} (0.48) [143]
Lower-medium	5.73 ^{b, c, d,***, e,***, f,***} (1.25) [4,989]	6.69 ^{b, c, d, e,***} (0.71) [775]	8.29 (0.84) [96]	6.10 ^{b,***, c} (0.72) [171]	3.35 ^{b, c, d, e} (0.85) [289]	0.76 (0.57) [119]	5.58 (0.71) [317]	5.64 (0.60) [284]	4.99 (0.48) [180]
Upper-medium	5.76 ^{c, d,***, e,***, f,***} (1.41) [1,269]	6.84 ^{c, d, e,***} (0.70) [231]		5.74 ^{c*} (0.65) [56]	3.33 ^{c, d, e} (0.74) [93]				
Big	5.62 ^{d, e,***, f,***} (1.56) [1,194]	6.67 ^{d, e,***} (0.57) [253]		6.08 (0.49) [58]	3.48 ^{d, e} (0.73) [172]				
Lower-large	5.46 ^{e,***, f,***} (1.75) [858]	6.82 ^{e,***} (0.60) [260]			3.41 ^e (0.57) [177]				
Upper-large	4.49 ^{f,***} (2.41) [620]	7.12 (0.60) [178]			3.43 (0.52) [190]				
Extreme-large	3.01 (2.24) [50]								
<i>continued</i>									
Firm size	(10) (Code 20)	(11) (Code 22)	(12) (Code 23)	(13) (Code 24)	(14) (Code 25)	(15) (Code 27)	(16) (Code 28)	(17) (Code 31)	
Small	6.90 ^{a***} (0.67) [217]	5.58 ^{a, b, c} (0.57) [148]	5.61 ^{a,***, b,***, c,***, d,***} (0.90) [559]	6.18 ^a (0.61) [67]	5.91 ^{a,***, b,***, c,***} (0.67) [532]	6.60 ^a (0.48) [58]	6.12 ^{a***} (0.58) [114]	4.46 ^{a, b, c, d} (0.61) [138]	
Lower-medium	6.73 (0.63) [215]	5.61 ^{b, c} (0.69) [271]	5.82 ^{b,***, c,***, d} (0.64) [1,311]	6.08 (0.52) [61]	5.43 ^{b,***, c,***} (0.58) [334]	6.66 (0.65) [130]	6.47 (0.59) [96]	4.34 ^{b,***, c,***, d} (0.71) [150]	
Upper-medium		5.62 ^c (0.59) [63]	5.98 ^{c, d} (0.64) [297]		5.23 ^c (0.45) [72]			4.66 ^{c, d} (0.81) [71]	
Big		5.62 (0.91) [60]	5.99 ^{c, d} (0.66) [243]		5.13 (0.52) [66]			4.68 ^d (0.55) [52]	
Lower-large			5.97 ^d (0.56) [106]					4.51 (0.87) [70]	

Note: Standard error in the parentheses, number of observations in the square brackets.

***, **, *: The averages are statistically different at the 1%, 5%, 10% level.

For multiple groups, the stars on 1st, 2nd and 3rd and so on groups from the top represent the averages between 1st and 2nd, 1st and 3rd, and 1st and 4th groups and so on are statistically different, respectively.

For example: a, b, c, d, e, f in column (1) denotes the difference between small firms and lower-medium firms, upper-medium firms, big firms, lower-large firms, upper-large firms, and extreme-large firms, respectively. The signal a in column (3) denotes the difference between small firms and lower-medium firms only.

Industry codes are as follows: 10: Food products; 11: Beverages; 13: Textiles; 14: Wearing apparel; 15: Leather and related products; 16: Wood and products of wood/cork; 17: Paper and paper products; 18: Printing and reproduction of recorded media; 20: Chemicals and chemical products; 22: Rubber and plastics products; 23: Other non-metallic mineral products; 24: Basic metals; 25: Fabricated metal products; 27: Electrical equipment; 28: Machinery and equipment n.e.c; 31: Furniture.

Source: Authors' estimation from VAES 2010-2016

The null hypothesis that TFP distance differs statistically among heterogeneous labor groups is again tested using analysis of variance (ANOVA). For the private sector as a whole, the tests show that significant labor heterogeneity in TFP distance exists for almost all of manufacturing sectors considered (some manufacturing sectors with small number observations are omitted from the analysis). Firm size in terms of labor indicates that SME firms have significantly different TFP distance from big and large ones, big firms are also significantly different from large ones in terms of TFP levels and lower-large firms are also significantly different from upper- and extreme-large ones in terms of TFP levels. TFP level increases as firm sizes change from a small firm to a medium firm, big firm and then to a large firm. Column 2 in Table 3 presents the result in food products (code 10). We find also that labor heterogeneity exists, indicating that SME firms have significantly different TFP distances from big and large ones, big firms are also significantly different from large ones in terms of TFP distances and lower-large firms are

also significantly different from upper- and extreme-large ones in terms of TFP distances. TFP distance increases as firm sizes change from a small firm to a medium firm, big firm and then to a large firm. Column 3 in Table 3 presents the result in beverages (code 11). We find that labor heterogeneity only happens between small and lower-medium firms. Similarity, we find that evidence with Leather and related products sector (code 15), Wood and products of wood/cork (code 16), Paper and paper products (code 17), Printing and reproduction of recorded media (code 18), Chemicals and chemical products (code 20), and Machinery and equipment n.e.c (code 28). In column 4 of Table 3, we observe that labor heterogeneity occurs in Textiles sector (code 13) between small and big firms. In column 5 of Table 3, Wearing apparel sector (code 14) does not show any evidence of labor heterogeneity over the range of labor size. We find no similar evidence in Rubber and plastics products (code 22), Basic metals (code 24), Electrical equipment (code 27). In column 12 of Table 3, we observe that labor heterogeneity occurs in Other non-metallic mineral products (code 23) between small and lower-medium firms. We find similar evidence Fabricated metal products (code 25) in column 14, and Furniture (code 31) in column 17.

Table 4

Labor heterogeneity in TFP distance (compared to top 3): Vietnamese manufacturing domestic private sector (2010-16)

Firm size	(1) All sectors	(2) (Code 10)	(3) (Code 11)	(4) (Code 13)	(5) (Code 14)	(6) (Code 15)	(7) (Code 16)	(8) (Code 17)	(9) (Code 18)
Small	5.90 ^{***, b, c, d, e, f} (1.16) [3,753]	5.96 ^{a, b, c, d, e} (0.74) [798]	7.87 ^{a, b, c, d, e, f} (1.07) [62]	5.28 ^{a, b, c, d, e} (0.73) [160]	2.64 ^{a, b, c, d, e} (0.67) [91]	0.92 ^{a, b, c, d, e, f} (0.48) [74]	4.68 ^{a, b, c, d, e, f} (0.76) [315]	4.57 ^{a, b, c, d, e, f} (0.64) [226]	4.05 ^{a, b, c, d, e, f} (0.48) [143]
Lower-medium	5.73 ^{b, c, d, e, f} (1.25) [4,989]	5.91 ^{b, c, d, e, f} (0.71) [775]	7.51 (0.84) [96]	5.32 ^{b, c, d, e, f} (0.72) [171]	2.57 ^{b, c, d, e, f} (0.85) [289]	-0.02 (0.57) [119]	4.80 (0.71) [317]	4.86 (0.60) [284]	4.21 (0.48) [180]
Upper-medium	5.76 ^{c, d, e, f} (1.41) [1,269]	6.06 ^{c, d, e, f} (0.70) [231]		4.96 ^{c, d, e, f} (0.65) [56]	2.55 ^{c, d, e, f} (0.74) [93]				
Big	5.62 ^{d, e, f} (1.56) [1,194]	5.89 ^{d, e, f} (0.57) [253]		5.30 (0.49) [58]	2.70 ^{d, e, f} (0.73) [172]				
Lower-large	5.46 ^{e, f} (1.75) [858]	6.04 ^{e, f} (0.60) [260]			2.63 ^{e, f} (0.57) [177]				
Upper-large	4.49 ^f (2.41) [620]	6.34 (0.60) [178]			2.65 (0.52) [190]				
Extreme-large	3.01 (2.24) [50]								
<i>continued</i>									
Firm size	(10) (Code 20)	(11) (Code 22)	(12) (Code 23)	(13) (Code 24)	(14) (Code 25)	(15) (Code 27)	(16) (Code 28)	(17) (Code 31)	
Small	6.12 ^{a, b, c, d, e, f} (0.67) [217]	4.80 ^{a, b, c, d, e, f} (0.57) [148]	4.83 ^{a, b, c, d, e, f} (0.90) [559]	5.40 ^{a, b, c, d, e, f} (0.61) [67]	5.13 ^{a, b, c, d, e, f} (0.67) [532]	5.82 ^{a, b, c, d, e, f} (0.48) [58]	5.34 ^{a, b, c, d, e, f} (0.58) [114]	3.68 ^{a, b, c, d, e, f} (0.61) [138]	
Lower-medium	5.95 (0.63) [215]	4.83 ^{b, c, d, e, f} (0.69) [271]	5.04 ^{b, c, d, e, f} (0.64) [1,311]	5.30 (0.52) [61]	4.65 ^{b, c, d, e, f} (0.58) [334]	5.88 (0.65) [130]	5.69 (0.59) [96]	3.56 ^{b, c, d, e, f} (0.71) [150]	
Upper-medium		4.84 ^{c, d, e, f} (0.59) [63]	5.20 ^{c, d, e, f} (0.64) [297]		4.45 ^{c, d, e, f} (0.45) [72]			3.88 ^{c, d, e, f} (0.81) [71]	
Big		4.84 (0.91) [60]	5.21 ^{c, d, e, f} (0.66) [243]		4.35 (0.52) [66]			3.90 ^{d, e, f} (0.55) [52]	
Lower-large			5.19 (0.56) [106]					3.73 (0.87) [70]	

Note: Standard error in the parentheses, number of observations in the square brackets.

***, **, *: The averages are statistically different at the 1%, 5%, 10% level.

For multiple groups, the stars on 1st, 2nd and 3rd and so on groups from the top represent the averages between 1st and 2nd, 1st and 3rd, and 1st and 4th groups and so on are statistically different, respectively. For example: a, b, c, d, e, f in column (1) denotes the difference between small firms and lower-medium firms, upper-medium firms, big firms, lower-large firms, upper-large firms, and extreme-large firms, respectively. The signal a in column (3) denotes the difference between small firms and lower-medium firms only.

Industry codes are as follows: 10: Food products; 11: Beverages; 13: Textiles; 14: Wearing apparel; 15: Leather and related products; 16: Wood and products of wood/cork; 17: Paper and paper products; 18: Printing and reproduction of recorded media; 20: Chemicals and chemical products; 22: Rubber and plastics products; 23: Other non-metallic mineral products; 24: Basic metals; 25: Fabricated metal products; 27: Electrical equipment; 28: Machinery and equipment n.e.c; 31: Furniture.

Source: Authors' estimation from VAES 2010-2016

Table 4, furthermore, presents average TFP distance, but TFP distance to the top 3 firms, for Vietnamese manufacturing private sector. The null hypothesis that TFP distance differs statistically among heterogeneous labor groups is again tested using analysis of variance (ANOVA). For the private sector as a whole, the tests show that significant labor heterogeneity in TFP distance exists for almost all of manufacturing sectors considered (some manufacturing sectors with small number observations are omitted from the analysis). Firm size in terms of labor indicates that SME firms have significantly different TFP distance from big and large ones, big firms are also significantly different from large ones in terms of TFP levels and lower-large firms are also significantly different from upper- and extreme-large ones in terms of TFP levels. TFP level increases as firm sizes change from a small firm to a medium firm, big firm and then to a large firm. Column 2 in Table 4 presents the result in food products (code 10). Unlike the case of top 1, we find that labor heterogeneity only exists between small, medium, big, and large firms and extreme-large one. Column 3 in Table 4 presents the similar result in beverages (code 11) as for the case of top 1. We find that labor heterogeneity only happens between small and lower-medium firms. Similarity, we find that evidence with Leather and related products sector (code 15), Wood and products of wood/cork (code 16), Paper and paper products (code 17), Printing and reproduction of recorded media (code 18), Chemicals and chemical products (code 20), Basic metals (code 24), and Machinery and equipment n.e.c (code 28). In column 4 of Table 4, we observe that labor heterogeneity occurs in Textiles sector (code 13) between small and big firms. In column 5 of Table 4, Wearing apparel sector (code 14) does not show any evidence of labor heterogeneity over the range of labor size. We find no similar evidence in Rubber and plastics products (code 22). In column 12 of Table 4, we observe that labor heterogeneity occurs in Other non-metallic mineral products (code 23) between small and lower-medium firms. We find similar evidence Fabricated metal products (code 25) in column 14, and, to some extent, Furniture (code 31) in column 17.

3.2.2. Labor heterogeneity in TFP dispersion

Table 5 presents average level of TFP dispersion for Vietnamese manufacturing private sector. The null hypothesis that TFP level of dispersion differs statistically among heterogeneous labor groups is tested using analysis of variance (ANOVA). In general, applying to the private sector in Column 1, the tests show that significant labor heterogeneity in TFP level of dispersion does not exist for almost all of manufacturing sectors considered (some manufacturing sectors with small number observations are omitted from the analysis), except for lower-medium and extreme-large firms. Column 2 in Table 5 presents the result in food products (code 10). We find that labor heterogeneity only exists between, group by group, small, medium, big, and large firms and extreme-large one. Column 3 in Table 5 presents the result in beverages (code 11). We find that labor heterogeneity only happens between small and lower-medium firms. Similarity, we find that evidence with Leather and related products sector (code 15), Wood and products of wood/cork (code 16), Paper and paper products (code 17), Printing and reproduction of recorded media (code 18), Chemicals and chemical products (code 20), and Machinery and equipment n.e.c (code 28).

In column 4 of Table 5, we observe that labor heterogeneity occurs in Textiles sector (code 13) between small and big firms.

Wearing apparel sector (code 14) in column 5 does not show any evidence of labor heterogeneity over the range of labor size. We find no similar evidence in Rubber and plastics products (code 22), and Basic metals (code 24).

Other non-metallic mineral products (code 23) in Column 12, and Fabricated metal products (code 25) in column 14 gives evidence of heterogeneity between small and medium firms.

Furniture (code 31) in column 17 gives evidence of heterogeneity between lower and upper-medium firms.

Table 5

Labor heterogeneity in TFP dispersion: Vietnamese manufacturing domestic private sector (2010-16)

Firm size	(1) All sec- tors	(2) (Code 10)	(3) (Code 11)	(4) (Code 13)	(5) (Code 14)	(6) (Code 15)	(7) (Code 16)	(8) (Code 17)	(9) (Code 18)
Small	0.01 ^{a, b, c, d, e, f} (0.75) [3,753]	0.02 ^{a, b, c, d, e***} (0.74) [798]	-0.14 ^{a**} (1.07) [62]	-0.00 ^{a, b**, c} (0.73) [160]	-0.02 ^{a, b, c, d, e} (0.67) [91]	-0.47 ^{a***} (0.48) [74]	0.09 ^{a*} (0.76) [315]	0.19 ^{a***} (0.64) [226]	0.08 ^{a***} (0.48) [143]
Lower-me- dium	0.02 ^{b, c, d, e**, f} (0.68) [4,989]	0.07 ^{b, c, d, e***} (0.71) [775]	0.22 (0.84) [96]	-0.04 ^{b***, c} (0.72) [171]	0.06 ^{b, c, d, e} (0.85) [289]	0.47 (0.67) [119]	-0.02 (0.71) [317]	-0.10 (0.60) [284]	-0.08 (0.48) [180]
Upper-me- dium	-0.04 ^{c, d, e, f} (0.67) [1,269]	-0.07 ^{c, d, e***} (0.70) [231]		0.33 ^{c*} (0.65) [56]	0.07 ^{c, d, e} (0.74) [93]				
Big	-0.02 ^{d, e, f} (0.67) [1,194]	0.09 ^{d, e***} (0.57) [253]		-0.02 (0.49) [58]	-0.08 ^{d, e} (0.73) [172]				
Lower- large	-0.04 ^{e, f} (0.62) [858]	-0.05 ^{e***} (0.60) [260]			0.00 ^e (0.57) [177]				
Upper- large	-0.08 ^f (0.65) [620]	-0.35 (0.60) [178]			-0.02 (0.52) [190]				
Extreme- large	0.11 (0.87) [50]								

continued

Firm size	(10) (Code 20)	(11) (Code 22)	(12) (Code 23)	(13) (Code 24)	(14) (Code 25)	(15) (Code 27)	(16) (Code 28)	(17) (Code 31)
Small	-0.11 ^{a***} (0.67) [217]	0.03 ^{a, b, c} (0.57) [148]	0.21 ^{a***, b**, c***, d***} (0.90) [559]	-0.06 ^a (0.61) [67]	-0.27 ^{a***, b**, c***} (0.67) [532]	-0.02 ^a (0.48) [58]	-0.29 ^{a***} (0.58) [114]	0.05 ^{a, b, c, d} (0.61) [138]
Lower-me- dium	0.06 (0.63) [215]	-0.00 ^{b, c} (0.69) [271]	-0.00 ^{b**, c**, d} (0.64) [1,311]	0.04 (0.52) [61]	0.20 ^{b*} (0.58) [334]	-0.07 (0.65) [130]	-0.06 (0.59) [96]	0.18 ^{b**, c*, d} (0.71) [150]
Upper-me- dium		-0.01 (0.59) [63]	-0.16 ^{c**, d} (0.64) [297]		0.40 ^c (0.45) [72]			-0.14 ^{c, d} (0.81) [71]
Big		-0.01 ^c (0.91) [60]	-0.17 ^d (0.66) [243]		0.51 (0.52) [66]			-0.16 ^{c, d} (0.55) [52]
Lower- large			-0.15 (0.56) [106]					0.01 (0.87) [70]

Note: Standard error in the parentheses, number of observations in the square brackets.

***, **, *: The averages are statistically different at the 1%, 5%, 10% level.

For multiple groups, the stars on 1st, 2nd and 3rd and so on groups from the top represent the averages between 1st and 2nd, 1st and 3rd, and 1st and 4th groups and so on are statistically different, respectively. For example: a, b, c, d, e, f in column (1) denotes the difference between small firms and lower-medium firms, upper-medium firms, big firms, lower-large firms, upper-large firms, and extreme-large firms, respectively. The signal a in column (3) denotes the difference between small firms and lower-medium firms only.

Industry codes are as follows: 10: Food products; 11: Beverages; 13: Textiles; 14: Wearing apparel; 15: Leather and related products; 16: Wood and products of wood/cork; 17: Paper and paper products; 18: Printing and reproduction of recorded media; 20: Chemicals and chemical products; 22: Rubber and plastics products; 23: Other non-metallic mineral products; 24: Basic metals; 25: Fabricated metal products; 27: Electrical equipment; 28: Machinery and equipment n.e.c; 31: Furniture.

Source: Authors' estimation from VAES 2010-2016

3. Conclusions and implication

This paper has examined the labor heterogeneity and productivity performance among domestic private firms in sixteen manufacturing sectors for the period 2010–2016, with a focus on labor heterogeneity and a use of some measures of TFP, namely TFP level, TFP distance and TFP dispersion. To this end, firm productivities are firstly estimated with the Akerberg-Caves-Frazer method (2015), using value added production. Our results indicate that, in the private sector, labor heterogeneity on productivity are very dependent on specific manufacturing sectors, and on type of TFP. Specifically, we find that labor heterogeneity of productivity level in a number of aspects: (1) labor heterogeneity exists, indicating that SME firms have significantly different TFP levels from big and large ones, big firms are also significantly different from large ones in terms of TFP levels and lower-large firms are also significantly different from upper- and extreme-large ones in terms of TFP levels in food products (code 10), (2) labor heterogeneity only happens between small and lower-medium firms (in beverages (code 11), Leather and related products sector (code 15) in column 6 gives evidence of heterogeneity between small and lower-medium firms. The same is found with Wood and products of wood/cork (code 16), Paper and paper products (code 17), Printing and reproduction of recorded media (code 18), Chemicals and chemical products (code 20)), (3) labor heterogeneity between small, lower-medium firms and upper-medium and big firms with Fabricated metal products (code 25); (4) labor heterogeneity occurs in Textiles sector (code 13) between small and big firms, and (5) No evidence of labor heterogeneity of productivity level is found in sectors such as: Wearing apparel sector (code 14), Basic metals (code 24), Electrical equipment (code 27), Machinery and equipment not yet classified (n.e.c) (code 28), and Furniture (code 31).

With respect to TFP distance, we find labor heterogeneity of productivity distance (top-1 distance) in manufacturing sectors: (1) labor heterogeneity exists, indicating that SME firms have significantly different TFP distances from big and large ones, big firms are also significantly different from large ones in terms of TFP distances and lower-large firms are also significantly different from upper- and extreme-large ones in terms of TFP distances in food products (code 10), (2) labor heterogeneity only happens between small and lower-medium firms in beverages (code 11), Leather and related products sector (code 15), Wood and products of wood/cork (code 16), Paper and paper products (code 17), Printing and reproduction of recorded media (code 18), Chemicals and chemical products (code 20), and Machinery and equipment n.e.c (code 28), (3) labor heterogeneity occurs in Textiles sector (code 13) between small and big firms, (4) labor heterogeneity occurs between small and lower-medium firms in Other non-metallic mineral products, Fabricated metal products (code 25), and Furniture (code 31), and (5) no evidence of labor heterogeneity over the range of labor size is found in Wearing apparel sector (code 14), Rubber and plastics products (code 22), Basic metals (code 24), Electrical equipment (code 27).

With respect to top-3 distance, we find labor heterogeneity of productivity distance in several ways: (1) labor heterogeneity only exists between small, medium, big, and large firms and extreme-large one, Unlike the case of top 1, in food products (code 10), (2) labor heterogeneity only happens between small and lower-medium firms in beverages (code 11) as for the case of top 1, Leather and related products sector (code 15), Wood and products of wood/cork (code 16), Paper and paper products (code 17), Printing and reproduction of recorded media (code 18), Chemicals and chemical products (code 20), Basic metals (code 24), and Machinery and equipment n.e.c (code 28), (3) labor heterogeneity occurs in Textiles sector between small and big firms, (4) labor heterogeneity occurs between small and lower-medium firms in Other non-metallic mineral products (code 23), Fabricated metal products (code 25), and, to some extent, Furniture (code 31), and (5) no evidence of labor heterogeneity over the range of labor size in Wearing apparel sector (code 14), and Rubber and plastics products (code 22).

Regarding TFP dispersion, our results indicate labor heterogeneity of productivity dispersion in manufacturing sectors, namely: (1) labor heterogeneity only exists between, group by group, small, medium, big, and large firms and extreme-large one food products (code 10), (2) labor heterogeneity only happens between small and lower-medium firms in beverages (code 11), Leather and related products sector (code

15), Wood and products of wood/cork (code 16), Paper and paper products (code 17), Printing and reproduction of recorded media (code 18), Chemicals and chemical products (code 20), and Machinery and equipment n.e.c (code 28), (3) no evidence of labor heterogeneity over the range of labor size is found in Wearing apparel sector (code 14), Rubber and plastics products (code 22), and Basic metals (code 24), (4) labor heterogeneity occurs in Textiles sector (code 13) between small and big firms, (5) heterogeneity between small and medium firms in Other non-metallic mineral products (code 23), and Fabricated metal products (code 25), and (5) Furniture (code 31) gives evidence of heterogeneity between lower and upper-medium firms. From an industrial policy perspective, there is hence productivity related reason why Vietnamese policy makers should prefer large and extreme-large firms over SMEs in some manufacturing and vice versa. Our results show a support for both SMEs and large private consortium, depending on specific manufacturing sectors. In addition, since there is strong evidence to suggest that labor heterogeneity in TFP exist in some manufacturing sectors, the rationality behind policies to support SMEs and large firms at every manufacturing sectors seems to be questionable.

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