WORKING PAPER No. 07

# Digital Economy and the Employment Effect of Inward FDI in China

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**November 2021**

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# Digital economy and the employment effect of inward FDI in China

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This version: Nov 2021

**Abstract:** This paper investigates how the development of digital economy shapes the employment impact of inward FDI in China. We first construct a set of comprehensive indexes to measure the development of digital economy with entropy method and coefficient of variation method. We then use a panel dataset covering 30 provinces from 2000 to 2019 and find that the development of digital economy significantly strengthens the positive effect of inward FDI on employment. Furthermore, this effect is shown to be more pronounced in the service sector than in the manufacturing sector, and relatively greater in west areas than east and central areas.

**Keywords:** Digital economy; Inward FDI; Employment

**JEL classification:** E24; O10; R10

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# I. Introduction

Traditional Heckscher–Ohlin (HO) framework indicates that the employment of low-skilled workers in developing countries should increase since the return to this relatively abundant resource (i.e. the low-skilled worker) will increase with the capital inflows from developed countries. In examining the HO theory, however, empirical studies show contradicting results (See, for example, Feenstra and Hansen 1997; Choi 2006; Figini and Gorg 2011; Wang, Fidrmuc, and Tian 2020; Wang, Fidrmuc, and Luo 2021 among others). This puzzle can be mainly explained by skill-bias technology change over the past decades especially with the rapid development of digital economy, which motivates us to probe further into this topic.

In this paper, therefore, we seek to explore how the development of digital economy in host countries shapes the employment effect of inward FDI. There are several contributions. First, the employment effect of inward FDI has been well documented in the literature but the findings do not concur. To this, we offer a new insight into this realm from the perspective of digital economy. The development of digital economy can reduce the costs of information search, production, transaction, and shipping, etc. (Jorgenson 2001; Goldfarb and Tucker 2019). By the same token, the development of digital economy can also enrich the market options for the investors, accelerate the mobility of investment flows and facilitate the job recruitment for the start-ups of the multinational enterprises. Second, the direct impact of skill-bias technology upgrading on labor market has been well documented. For example, some studies find that the adoption of industrial robots leads to declining demand for unskilled workers while increase the demand for skilled workers (Autor 2015; Acemoglu and Restrepo 2018). Although digital economy is in principle defined as economic activities involved with the adoption of the digital technology, the literature is lack of a comprehensive measure for the digital economy. To this, we construct comprehensive indexes to measure the development of digital economy at sub-national level, which allows us to compare the regional heterogeneity. Last, our empirical strategy focuses on China, the largest emerging economy that has important implications for other economies. On the one hand, taking the advantage of low labor price and the huge market share, China has become one of the largest FDI recipients globally. On the other hand, China's investment and innovation in digital economy such as robotic automation, 5G information technology and cloud payment mode has gained increasing global influence in recent years.

The rest of the paper proceeds as follows. The next section presents the calculating process of measuring the digital economy development and the empirical strategy. Section three discusses the estimation results. Section four concludes.

## II. Data and methodology

### *2.1. Measurement of digital economy development*

Since digital economy is broadly defined as economic activities consisting of ICT infrastructure, e-commerce and digital media (Jorgenseon 2001; Barefoot et al. 2018), we select 15 indicators from 4 dimensions, namely, digital infrastructure, digital industry, digital innovation and digital application to construct a set of comprehensive indexes of digital economy development, shown in Table1. Based on this framework, we adopt entropy method to measure the digital economy, while using coefficient of variation method as robustness check (Hao, Li, and Chen 2021).

The calculating process of the digital economy development measured by entropy method contains 4 steps. ①The first step is data standardization processing. Given the measuring units' inconsistencies of different second-level indexes, raw data are standardized according to the method as follows, which is to make the indexes comparable.

$$X'_{ijt} = \begin{cases} \dfrac{X_{ijt} - \min(X_j)}{\max(X_j) - \min(X_j)}, & \text{if } X_{ijt} \text{ is positive index.} \\ \dfrac{\max(X_j) - X_{ijt}}{\max(X_j) - \min(X_j)}, & \text{if } X_{ijt} \text{ is negative index.} \end{cases} \tag{1}$$

Where $i$ denotes the $i^{th}$ province ($i$=1,...,30). $j$ denotes the $j^{th}$ second-level index ($j$=1...,15). $t$ denotes the $t^{th}$ year ($t$=2000..., 2019). $X_{ijt}$ and $X'_{ijt}$ denote the original index and the standardized index, respectively. $\max(X_{ijt})$ and $\min(X_{ijt})$ represent the maximum value and the minimum value. ②The second step is calculating the information entropy $e_j = -k\sum_t^m (Y_{jt} \times lnY_{jt})$, where $Y_{jt} = X_{jt} \Big/ \sum_t^m X_{jt}$, $k = 1/lnm$, $m$ denotes the number of years. ③The third step is calculating the weight $W_t$ of each indexes following $W_t = d_j / \sum_j^n d_j$, where $d_j = 1 - e_j$. ④The final step is to calculate comprehensive index, that is the development of digital economy $DE_{it}^E = \sum_j^n S_{ijt}$, where $S_{ijt} = W_t \times X_{ijt}$.

The calculating process of the digital economy development measured by coefficient of variation method contains five steps. ① The first step is data standardization processing. ②The second step is to calculate the coefficient of variation $CV_{jt}$ and the weight $\omega_{jt}$ of each second-level indexes following $CV_{jt} = \sigma_{jt} / \bar{X}_{jt}$ and $\omega_{jt} = CV_{jt} \Big/ \sum_{j}^{n} CV_{jt}$ , where $\sigma_{jt}$ and $\bar{X}_{jt}$ represent the standard deviation and the mean of each second-level indexes. ③The third step is to calculate each first-level indexes $Y_{i\eta t}$ following $Y_{i\eta t} = \sum_{j}^{n} \omega_{jt} X'_{ijt}$ , where $\eta$ denotes the $\eta^{\text{th}}$ first-level index ($\eta$=1,...,4). ④The fourth step is to calculate the coefficient of variation $CV'_{\eta t}$ and the weight $\theta_{\eta t}$ of each first-level indexes following $CV'_{\eta t} = \sigma'_{\eta t} / \bar{Y}_{\eta t}$ and $\theta_{\eta t} = CV'_{\eta t} \Big/ \sum_{\eta}^{p} CV'_{\eta t}$ , where $\sigma'_{\eta t}$ and $\bar{Y}_{\eta t}$ denote the standard deviation and the mean of each first-level indexes. ⑤The final step is to calculate comprehensive index, which is the development of digital economy $DE_{it}^{CV} = \sum_{\eta}^{p} \theta_{\eta t} Y_{i\eta t}$ .

The trend of digital economy development captured by the above methods from 2000 to 2019 is shown in Fig.1. The digital economy indexes increase during the past decades and they grow in a more rapid manner since 2015. Coastal (eastern) regions have witnessed more developed digital economy than inland regions.

**Table 1.** The comprehensive index of digital economy development.

| Digital economy index | 1st level indexes | 2nd level indexes |
|---|---|---|
| Development of digital economy | Infrastructure | Number of broadband Internet access ports |
| | | Length of long-distance optical cable line |
| | | Number of domain names per ten thousand people |
| | | Number of websites per ten thousand people |
| | | Mobile phone penetration rate |
| | | Internet penetration rate |
| | Industry | Telecommunication services |
| | | Software and information technology services revenue scale |
| | | The fraction of the electronic information manufacturing income in the manufacturing sector |
| | Innovation | Number of patents granted about 5G industry |
| | | Number of patents granted about industrial internet |
| | | Number of patents granted about e-commerce |
| | Application | Number of websites per hundred companies |
| | | E-commerce sales scale |
| | | Express business scale |

Source: The data for digital infrastructure and digital application are from National Bureau Statistics of China; the data for digital industry is from China Information Yearbook; the data for digital innovation is from Qiyandata - Digital Economy Industry Database.

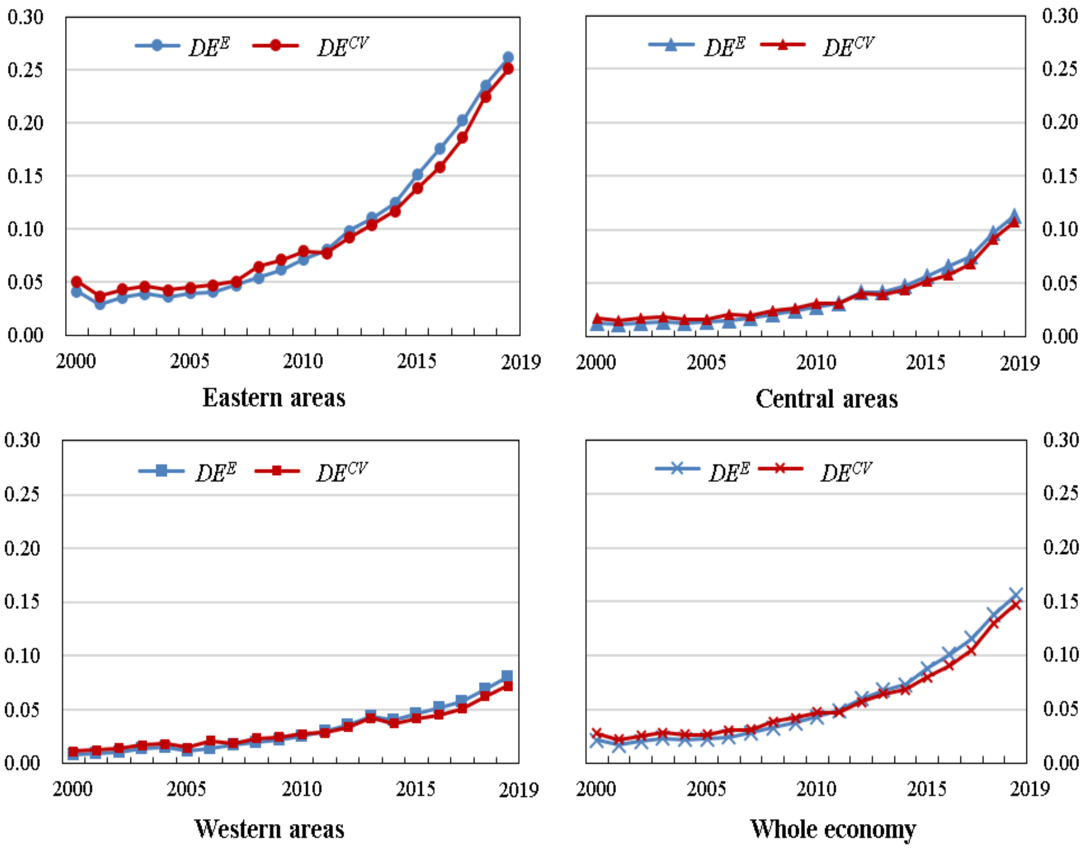


**Fig.1.** The development of digital economy from 2000-2019.

Notes: 1. Left axis: $DE^E$ denotes the level of digital economy development measured by entropy method. Right axis: $DE^{CV}$ denotes the level of digital economy development measured by coefficient of variation method.

*2.2. Empirical Model*

Based on the dataset that covers 30 provinces in China from the period of 2000 to 2019, we conduct a panel data analysis to investigate how digital economy influences the employment effect of inward FDI. The empirical model is set up as follows.

$$\begin{aligned} EMP_{it} &= \alpha_0 + \alpha_1 FDI_{it\text{-}1} \times DE_{it\text{-}1} + \alpha_2 DE_{it\text{-}1} + \alpha_3 FDI_{it-1} + \alpha_4 GDP_{it} \\ &+ \alpha_5 HC_{it} + \alpha_6 TRA_{it} + \alpha_7 W_{it} + \gamma_i + \lambda_t + \varepsilon_{it} \end{aligned} \quad (2)$$

**Table 2.** Descriptive statistics.

| Variables | Description | Obs. | Mean | Std. Dev. |
|---|---|---|---|---|
| $EMP$ | Total employment (ten thousand people) | 600 | 272.053 | 491.082 |
| $EMP^M$ | Manufacturing sector employment (ten thousand people) | 600 | 105.953 | 279.804 |
| $EMP^S$ | Service sector employment (ten thousand people) | 600 | 157.337 | 382.070 |
| $DE^E$ | Digital Economy index measured by entropy method | 600 | 0.057 | 0.073 |
| $DE^{CV}$ | Digital Economy index measured by coefficient variation method | 600 | 0.057 | 0.071 |
| $FDI$ | Foreign direct investment in whole economy (hundred million USD) | 600 | 60.160 | 78.928 |
| $FDI^M$ | Foreign direct investment in manufacturing sector (hundred million USD) | 600 | 33.122 | 47.590 |
| $FDI^S$ | Foreign direct investment in manufacturing sector (hundred million USD) | 600 | 28.667 | 50.601 |
| $GDP$ | Gross Domestic Product (hundred million USD) | 600 | 2185.208 | 2520.017 |
| $GDP^M$ | Gross Domestic Product in manufacturing sector (hundred million USD) | 600 | 958.397 | 1135.048 |
| $GDP^S$ | Gross Domestic Product in service sector (hundred million USD) | 600 | 1036.440 | 1294.624 |
| $HC$ | Labourers holding college degree (ten thousand people) | 600 | 2.807 | 0.870 |
| $TRD$ | Export-output ratio (%) | 600 | 0.056 | 0.072 |
| $W$ | Wage (ten thousand USD) | 600 | 0.247 | 0.075 |

Source: National Bureau of Statistics of China.

Where $EMP_{it}$ denotes the employment in province $i$ at time $t$. $DE_{it\text{-}1}$ refers to the digital economy development indexes including two variations, namely $DE^E$ and $DE^{CV}$. $FDI_{it\text{-}1}$ denotes foreign direct investment, while $GDP_{it}$ represents economic scale. We adopt $HC_{it}$ measured by the fraction of people holding higher education diploma to define human capital. $TRA_{it}$ and $W_{it}$ are proxies for the export-output ratio and average annual wage respectively. $\gamma_i$ denotes the province fixed effect, $\lambda_t$ denotes the time fixed effect. The descriptive statistics are reported in Table 2.

## III. Empirical results

The results of the impact of digital economy on employment effect of inward FDI are reported in table 3. We first consider the effect in whole economy, the manufacturing sector and the service sector, respectively. As shown in columns (1)-(6), the coefficients of $DE^E$ and $DE^{CV}$ are positive and statistically significant at 1% level in all columns, showing that the development of digital economy has a positive effect on employment. Our results show that *FDI* has a positive effect on employment, which is consistent with previous findings (Choi 2006; Wang, Fidrmuc and Tian 2020). The variable of main interest, the interaction term between *DE* and *FDI* shows a positive sign, meaning that the development of digital economy reinforces the employment effect of inward FDI. This is in line with the arguments of Goldfarb and Tucker (2019) in the sense that the development of digital economy can lead to cost reduction, market expansion, industrial upgrading, thereby facilitating the flow of FDI and creating new jobs. Notably, the positive impact of digital economy in shaping the employment effect of inward FDI is larger in the service sector than in the manufacturing sector. There are two main reasons behind. On the one hand, the service sector in China is still at a less developed stage, showing greater elasticity in unskilled labor supply. On the other hand, the prevalence rate of digital technology adoption in service sector weighs higher than that in the manufacturing sector at this stage, creating more relevant job opportunities for the labor market.

To consider the regional heterogeneity, we separate the sample into east, central and west China. The results reported in columns (7)-(12) show that the coefficients of $DE^E$, $DE^{CV}$, *FDI* and their interaction term maintain positive sign in all columns, which is consistent with our previous estimations. We detect that the effect of digital economy is most pronounced in western areas among other areas. Our interpretation for this is straight forward. Comparatively, the digital economy in western areas is less developed and therefore the return on investment in digital economy is relatively higher. Taken together, our results complement the extant findings in the following sense. In supporting the view that the employment increases as the flow of inward FDI grows, we highlight that digital economy is one of the channels that shape the employment effect of inward FDI rather than re-examine the direct effect of digital economy on the employment (see e.g., Dammert, Galdo, and Galdo 2013; Shapiro and Mandelman 2021).

## IV. Conclusions

This paper investigates how the development of digital economy shapes the employment effect of inward FDI in China by developing a set of comprehensive indexes to measure the development of digital economy. Based on the panel dataset pertaining to 30 provinces from 2000 to 2019, we find consistent evidence that the development of digital economy overall significantly strengthens the positive employment effect of inward FDI. Further, this effect is more salient in the service sector than in the manufacturing sector. Besides, the positive employment effect in western areas is larger than other areas with the rapid development of digital economy.

**Table 3.** Digital economy and employment effect of inward FDI.

| | Whole economy | | Manufacturing sector | | Service sector | | East China | | Central China | | West China | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
| $DE^E$ | 1.666*** | | 1.138*** | | 1.438*** | | 0.874** | | 0.616** | | 1.887*** | |
| | (0.244) | | (0.267) | | (0.219) | | (0.435) | | (0.294) | | (0.498) | |
| $DE^{CV}$ | | 1.727*** | | 1.121*** | | 1.567*** | | 1.224** | | 0.607* | | 2.111*** |
| | | (0.283) | | (0.301) | | (6.29) | | (0.517) | | (0.329) | | (0.577) |
| $FDI$ | 1.151*** | 1.152*** | 0.594*** | 0.550*** | 0.823*** | 0.886*** | 0.849*** | 1.010*** | 0.427** | 0.419** | 0.936*** | 1.006*** |
| | (0.141) | (0.159) | (0.141) | (0.153) | (0.092) | (8.29) | (0.246) | (0.276) | (0.181) | (0.191) | (0.241) | (0.269) |
| $DE^E \times FDI$ | 0.251*** | | 0.141*** | | 0.169*** | | 0.135* | | 0.087* | | 0.230*** | |
| | (0.034) | | (0.035) | | (0.025) | | (0.073) | | (0.046) | | (0.060) | |
| $DE^{CV} \times FDI$ | | 0.257*** | | 0.132*** | | 0.189*** | | 0.197** | | 0.088* | | 0.255*** |
| | | (0.041) | | (0.039) | | (6.41) | | (0.089) | | (0.051) | | (0.069) |
| $GDP$ | 0.910*** | 0.879*** | 1.176*** | 1.161*** | 0.687*** | 0.661*** | 1.506*** | 1.504*** | -0.695*** | -0.690*** | 1.135*** | 1.236*** |
| | (0.224) | (0.226) | (0.260) | (0.260) | (0.238) | (2.77) | (0.185) | (0.184) | (0.171) | (0.172) | (0.342) | (0.337) |
| $HC$ | 0.611*** | 0.598*** | 0.686*** | 0.698*** | 0.812*** | 0.808*** | -0.391*** | -0.381*** | 0.846*** | 0.814*** | 0.891*** | 0.856*** |
| | (0.123) | (0.124) | (0.143) | (0.144) | (0.132) | (6.08) | (0.129) | (0.127) | (0.164) | (0.162) | (0.283) | (0.282) |
| $TRA$ | -0.960*** | -0.963*** | -0.880*** | -0.882*** | -0.964*** | -0.964*** | -0.367*** | -0.367*** | -0.549*** | -0.538*** | -0.830*** | -0.826*** |
| | (0.061) | (0.062) | (0.071) | (0.071) | (0.063) | (-15.12) | (0.079) | (0.079) | (0.059) | (0.059) | (0.110) | (0.111) |
| $W$ | 0.509** | 0.464* | 0.657** | 0.599** | 0.673** | 0.641** | 0.397 | 0.415* | 0.015 | 0.011 | -2.992*** | -3.076*** |
| | (0.251) | (0.253) | (0.295) | (0.296) | (0.265) | (2.41) | (0.241) | (0.239) | (0.237) | (0.238) | (0.675) | (0.676) |
| Province fixed | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Year fixed | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Obs. | 570 | 570 | 570 | 570 | 570 | 570 | 209 | 209 | 152 | 152 | 209 | 209 |
| $R^2$ | 0.447 | 0.435 | 0.357 | 0.352 | 0.407 | 0.401 | 0.472 | 0.477 | 0.841 | 0.840 | 0.730 | 0.728 |

**Notes**: 1. Significance: *10%, **5%, ***1%. 2. Robust standard errors are in parentheses. 3. All variables are estimated in log form.

## Declaration of conflict interest

The authors report no conflict of interest.

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