Research on the Effect of Internet Development on Labor Productivity

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Abstract. With the implementation of the “Internet plus” strategy, an unprecedented digital revolution is spreading like a storm in China. Based on the panel data of China’s 31 provinces from 2003-2014, this paper empirically study the influence of Internet penetration rate on labor productivity, and compares the differences between the eastern, middle and western regions. The results show that the Internet penetration rate has a significant positive impact on the labor productivity. In the long run, assuming other factors stay constant, increasing the Internet penetration rate by one percent increases the labor productivity by about 0.357%, that is, the average annual output of each worker increased about 35.7 yuan. And this positive effect is different between regions, the eastern is the largest, followed by the central, and the western is the minimum. Finally, the paper puts forward some corresponding countermeasures and suggestions on the basis of the empirical analysis.

Introduction

In 2015, with the “Internet plus” strategy proposed by Premier Li Keqiang and the World Internet Conference held in Wuzhen, an unprecedented digital revolution is spreading like a storm in China. Since 1990s, Internet in our country began to rise and has developed rapidly. Until December 2015, the Internet users in our country have reached 688 million, and the Internet penetration rate has reached 50.3%. The network has covered 31 provinces in all regions and most of the townships. The technological revolution brought about by the Internet profoundly affected and changed people’s lifestyle. Specifically, the Internet can reduce the transaction cost between enterprises and the search costs of the supply and demand sides. What’s more, it can also shorten the transaction time and distance. Thus the Internet can increase the economic efficiency and the total output.

Labor productivity is not only an important method to measure the economic efficiency, but a significant economic development indicator of a country or region. Known economist Lin Yifu had said that “The essence of the economic growth is the level of continuous improvement of labor productivity, and the labor productivity must rely on technological innovation and industrial upgrading”. At present, Internet is gradually penetrating to and challenging the traditional industries, at the same time, some new economic approaches based on Internet begin to rise. Then with the proliferation of Internet wave, how much can the shock in technology influence labor productivity? Can it bring the improvement of the labor productivity? And are there some differences between regions? Given the data available, the paper will pick up data from China’s 31 provinces during 2003 to 2014 to study the relationship between Internet development and labor productivity.

Literature Review

The Internet, as a typical technology of general purpose, has obvious externalities and spillover effects (Androutsos, 2011).

In terms of the impact of the Internet on the economy and labor productivity, there are some differences in the estimates of foreign scholars, but most of them show that the development of the Internet has a positive effect on economic growth. Using the panel data of 207 countries in 1991-2000, Choi and Yi (2009) found that increasing 10% of the Internet penetration rate increased
the per capita GDP growth rate by 0.49%-0.59%. Kolko (2012) using the data from the United States since 1999 to 2006, researched on the relationship between broadband expansion and local economic growth, showing that there is a positive correlation between them, especially in the information technology industry and the low population density area. Ceccobelli, Gitto and Mancuso (2012) collected data from 14 OECD Member States, using non parametric methods, studying the influence of information and communication technology on labor productivity from 1995 to 2005. The results showed that the increase of information and communication technology had a positive effect on labor productivity. Najarzadeha Reza (2014) found that assuming other factors stay constant, when the number of Internet users increased by 1% can increase GDP per capita 8.165-14.6 $ by using the panel data of 108 countries in 1995-2010. There was a positive correlation between the development of the Internet and labor productivity.

Most of the domestic scholars analyzed the impact of the Internet on labor productivity from the perspective of qualitative and the empirical researches are not many. On the basic resources of China's Internet data from 2001 to 2010, Liu Yu (2010) found that the Internet resources index increased by 1% can drive GDP growth of 0.045%. Han Baoguo, Zhu Pingfang (2014) studied on the relationship between broadband and economic growth by using China's provincial panel data (2000-2011), and the results showed that increasing broadband penetration rate by 10% increased per capita annual growth rate of GDP by 0.19%.

In a word, we can see there is a close relationship between the Internet and the economic growth, especially the labor productivity. Most of the foreign scholars do research with the transnational panel data, the method of which is more scientific, but most of their data are collected from developed countries, and there is not too much concentration about the impact of the Internet on economic less-developed countries. Furthermore, there are less domestic researches on the relationship between Internet development and regional labor productivity. In this paper, we will use China's provincial panel data 2003-2014 to do an empirical analysis of the relationship between Internet penetration rates and labor productivity, and put forward some corresponding policy recommendations.

Model setting and Data description

Model setting

The effect of Internet on labor productivity has been studied by some foreign scholars, such as Arvanitis and Loukis (2009), Ceccobelli, Gitto and Mancuso (2012), Reza Najarzadeha et al (2014). In this paper, we assume that the Internet penetration rate (NET), average years of education (EDU) and population density (PD) are all positively associated with the labor productivity (LP). We take the logarithm of the variables based on the hypothesis in order to eliminate the influence of the heteroscedasticity and reflect the elastic relationship between the independent variables and the dependent variables. So the panel data models are setting as following:

$$\ln LP_{it} = \alpha_i + \beta_1 \ln NET_{it} + \beta_2 \ln EDU_{it} + \beta_3 \ln PD_{it} + \varepsilon_{it}$$

i=1,2…31; t=2003,2004…2014

Where i denotes the number of provinces (i=1-31), t is the time period (t=2003-2014). LP_{it} is the labor productivity (average annual output per employed person). Taking 1999 as the based period, we adopt the ratio of regional real GDP to employment to measure the real regional labor productivity, and the data are collected from the "China Statistical Yearbook". NET_{it} is the Internet penetration rate (ratio of local Internet users to the resident population), and the data come from the yearly Statistical report on the development of Internet announced by the China Internet Network Information Center (CNNIC). EDU_{it} denotes the average years of education. The data are collected from 2003-2014 educational statistics yearbook of China and the calculation method are referenced to the first method of Liu Wei (2003). PD_{it} is the population density. The data are sorted out on the basis of the annual statistical bulletin of the national economic and social development of each province. $\alpha_i$
is the individual differences which do not vary as the time changing. $\beta_1$ is the elasticity coefficient of the Internet penetration rate to labor productivity. $\epsilon_{it}$ is the random error.

**Data description**

We will do empirical analysis based on the panel data collected from China’s 31 provinces during 2003-2014, and the description is shown in Table 1 below. Firstly we will consider the impact of the Internet on labor productivity at the national level and then divided them into three regions as eastern, middle and western according to the relevant standards issued by National Bureau of Statistics of China.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Average</th>
<th>Maximum</th>
<th>Minimum</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>LP</td>
<td>3.926267</td>
<td>16.50761</td>
<td>0.283577</td>
<td>372</td>
</tr>
<tr>
<td>NET</td>
<td>26.6%</td>
<td>75.3%</td>
<td>2.2%</td>
<td>372</td>
</tr>
<tr>
<td>EDU</td>
<td>8.36</td>
<td>12.03</td>
<td>3.74</td>
<td>372</td>
</tr>
<tr>
<td>PD</td>
<td>417.785</td>
<td>3826.197</td>
<td>2.229508</td>
<td>372</td>
</tr>
</tbody>
</table>

From Table 1, We can see that the annual average labor productivity of 31 provinces 2003-2014 is 39300 yuan per person, the maximum is 16500 yuan per person (the labor productivity in Shanghai 2014) and the minimum is 0.28 yuan per person (the labor productivity in Guizhou province 2003). Due to the large time span and regional uneven development, there are big gaps between the maximum and the minimum value of the Internet penetration rate and the population density. Since the Internet was just arisen in 2003, the penetration rate in remote areas was very low, as the minimum is 2.2% (the data of Guizhou 2003). While with the rapid development of Internet in eastern, the maximum has been reached 75.3% (Beijing 2014). The per capita education year in China 2003-2014 is 8.26 which is consistent with the current nine-year compulsory education policy. The minimum is 3.74 (Xizang 2005) and the maximum is 12.03 (Beijing 2013). Given the big differences of topography and geomorphology, there are big gaps of population density among regions. The bulk of the population concentrates in the eastern coastal cities, so that the minimum of the population density in Xizang 2003 was only 2.23 people per kilometers while the maximum in Shanghai 2014 is 417.785.

The empirical study

Compared with time-series data and cross-sectional data, panel data has enough sample size. And it has the advantages of solving the problem of missing variables and the ability to reflect the dynamic behavior of individuals with the large sample capacity. However, we also encounter some problems. The most common one is how to deal with the “individual effects”. The panel data can be divided into mixed effect model, fixed effect model and random effect model. Mixed regression modes consider that regression coefficient and intercept are the same for any individuals without accepting differences between regions. Fixed effects (FE) and random effects (RE) take into account the individual differences between regions and bring the “individual effect” into models. The difference between the two models mainly lies in the hypothesis of the existence of the “individual effect”. Hausman test whose null-hypothesis is for random effects determines which model to be selected. If the test results reject the null-hypothesis, we should reject the random-effects and choose the fixed-effect model to estimate parameters. Otherwise we will accept the null-hypothesis and select the random effects model.

The results of the overall regression of 31 provinces in China are shown in Table 2(2). Model (2) is the result of fixed effects (FE), and the prob. is 0, so we reject the mixed OLS estimation. Next we consider about the existence of individual fixed effects. The regression results of the eastern, central and western regions are shown in Table 2 (3), (4), (5) separately. According to the results of Housman test, we choose fixed effect model for model (3) and (5), and random effects for model (4). We can
see from the regression results of fixed effects and random effects, the coefficients of $R^2$ are all higher than 0.95. So that we can say the models have a good reliability. The mixed OLS estimation is shown in Table 2 model (1) as a control.

Table 2. The regression results.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Model(1)</th>
<th>Model(2)</th>
<th>Model(3) Eastern</th>
<th>Model(4) Middle</th>
<th>Model(5) Western</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-1.290***</td>
<td>-1.676***</td>
<td>-3.642***</td>
<td>-2.792*</td>
<td>5.287***</td>
</tr>
<tr>
<td></td>
<td>(-3.381)</td>
<td>(-2.427)</td>
<td>(-5.022)</td>
<td>(-2.034)</td>
<td>(3.059)</td>
</tr>
<tr>
<td>LnNET</td>
<td>0.442***</td>
<td>0.357***</td>
<td>0.3890***</td>
<td>0.348***</td>
<td>0.338***</td>
</tr>
<tr>
<td>LnEDU</td>
<td>1.535***</td>
<td>0.952***</td>
<td>1.396***</td>
<td>1.274***</td>
<td>0.774***</td>
</tr>
<tr>
<td></td>
<td>(7.940)</td>
<td>(6.074)</td>
<td>(5.485)</td>
<td>(4.749)</td>
<td>(2.936)</td>
</tr>
<tr>
<td>LnPD</td>
<td>-0.013</td>
<td>0.267**</td>
<td>0.497***</td>
<td>0.072*</td>
<td>0.195***</td>
</tr>
<tr>
<td></td>
<td>(-0.734)</td>
<td>(2.166)</td>
<td>(4.523)</td>
<td>(-2.127)</td>
<td>(-3.192)</td>
</tr>
<tr>
<td>R2</td>
<td>0.66611</td>
<td>0.978830</td>
<td>0.97875</td>
<td>0.95320</td>
<td>0.96969</td>
</tr>
<tr>
<td>Hausman-test</td>
<td>22.2886</td>
<td>9.7158</td>
<td>1.2564</td>
<td>11.5598</td>
<td></td>
</tr>
<tr>
<td>Samples</td>
<td>372</td>
<td>372</td>
<td>156</td>
<td>72</td>
<td>144</td>
</tr>
<tr>
<td>Notes</td>
<td>Pooled OLS</td>
<td>FE</td>
<td>FE</td>
<td>RE</td>
<td>FE</td>
</tr>
</tbody>
</table>

T-statistics are reported in parentheses. ***, **, * represent 1%, 5% and 10% significance levels, respectively.

We can get some conclusions from Table 2. First of all, the key variable Internet penetration rate has a significant positive impact on labor productivity. At the national level, Internet penetration rate increasing by one percentage point increases labor productivity by about 0.357%. That means the average output per worker increases by 35.7 yuan per year. This result confirms the qualitative analysis of the scatter plot and is consistent with our expectations.

Secondly, the coefficient of education years and population density are both significantly positive as shown in model (2). As expected, it shows that the increase of per capita years of schooling helps to improve the labor productivity. Although the mixed OLS model also confirms the positive correlation between the development of the Internet and labor productivity, the coefficients of population education and population density are significantly negative. The longer the per capita years of education, the lower the labor productivity are obviously against our expectation. And the $R^2$ of the pooled OLS model is smaller, which means the model does not have a good reliability.

Due to the unbalanced development of regional economy in our country, now we will consider the influence of Internet development on regional labor productivity in the east, the middle and the west separately. As we can see in model (3), (4), (5), the impact of Internet development on labor productivity in the three regions is all significantly positive. Whether in the eastern, western or central, the increase of Internet penetration rate can all bring the improvement of labor productivity. But the effect is different in different regions. The leading role of the Internet on labor productivity is most obvious in eastern, when the Internet penetration rate increases by one percent increasing labor productivity by about 0.389%. The middle region takes the second place and is 0.348%. The western region is the lowest 0.348%. We think this result is mainly related to the uneven development of regional resources, infrastructure, industrial structure, industrialization level and so on which resulting the differences in the development of the Internet to improve labor productivity in different regions. The influence of Per capita education level and population density on labor productivity is roughly consistent with the national sample. Whether it is in the eastern, the middle and the western, the average education years and population density are both have a significant positive impact on labor productivity.
Conclusions and policy recommendations

This paper uses the panel data of China’s 31 provinces from 2003 to 2014 to study the influence of the development of the Internet on the labor productivity, and then analyzes the different impact of the Internet penetration rate on the labor productivity in east, middle and west regions. The results are shown as following:

(1) Internet penetration rate has a significant positive impact on labor productivity. Whether for the whole country or the three regions of China, such as the eastern, the middle and the western as a whole alone, the Internet penetration rate all has a significant positive impact on the labor productivity. The development of the Internet gave birth to the non-boundary organizations, which reduces the transaction cost. In the long term, the Internet penetration rate increasing by one percentage point increases the labor productivity by about 0.357%.

(2) The influence of Internet on labor productivity in the three regions is different. The Internet penetration rate is not high in less developed areas where the infrastructure is weak, technical level is low, and is lack of talents. Therefore, the popularity of the Internet brings about a limited increase in labor productivity. The economically developed eastern regions enjoy a convenient location conditions, and now are in the middle and late stage of industrialization development. Thus eastern regions have good infrastructure resources and industrial structure, where "Internet plus" plan has a significantly positive externalities and the development of the Internet has made a significant contribution to the improvement of labor productivity.

According to above conclusions, the paper puts forward some corresponding policy recommendations to enhance the role that Internet has on the boost of the labor productivity.

(1) Strengthen the infrastructure construction. In order to promote the popularization of the Internet, government should increase financial subsidies for the construction and promotion of the Internet, strengthen the construction of the Internet network infrastructure and decrease the cost of Internet access to expand the network needs, especially in economically underdeveloped areas and rural areas. We hope that though the efforts of the government, the digital divide between the eastern, middle and the western, as well as, the urban and rural areas can be narrowed. With the effort, everyone can benefit from the "Internet plus" strategy and make full use of the Internet to improve the labor productivity in China.

(2) Further promote the implementation of the integration strategy of industry and information technology. Compared with undeveloped areas, economy developed areas which are in the late stage of industrialization development have a good infrastructure construction and advanced industrial structure, so that the Internet has a more obvious spillover effect on labor productivity. Given the fact that the short board effect is often the biggest obstacle to economic growth, the government should strengthen the investment in infrastructure, human capital, financial capital, business environment, and improve the Internet penetration rate of the central and western regions. On one hand, underdeveloped areas should continue to promote the construction of the Internet, increase the Internet penetration rate and improve the level of information. On the other hand, efforts should be made to optimize the existing unreasonable industrial structure and promote the integration of information technology and industrialization. At the national level, our government should promote the effective combination of "Internet plus manufacturing" which will rely on the advantages of the Internet to promote the transformation and upgrading of traditional manufacturing industry in China. That will in turn make full use of the existing demographic dividend advantage, and make the manufacturing industry be bigger and stronger. Finally, it will improve the labor productivity and improve the coordinated development of China’s economy.

(3) Train high-level Internet application talents. If there are not enough talents matching with the good infrastructure, the role of the Internet to promote labor productivity growth is also difficult to play. The per capita level of education not only affects the level of regional labor productivity, but also influences the labor productivity through the use of the Internet. The average age of education in the underdeveloped areas of the west in China is relatively low. The government should increase investment in education expenditure in the western region to improve their education level in order to
make the internet better used. Internet penetration rate has slowed down since 2011. As known, programmers are the main body of the Internet innovations. We need to increase the training of high level talents to realize deeper and more long-term development of the advantages of the Internet.

(4) Strengthen the supervision of information security. In the process of promoting the popularization of the Internet, government must strengthen the supervision of information security to ensure that everyone and every company who trade, entertainment or work by the internet which also call “the virtual network” can remain the greatest trust. This will enhance people's confidence in the use of the Internet, which can improve the Internet penetration rate. And finally it will in turn improve the labor productivity and promote the rapid growth of economy.

References


