Information Technology Education and Impact in U.S.A.

Xiuling Yin[1] and Zhaoran Xu[2](✉)

[1] Shandong University of Political Science and Law, Jinan, China
[2] University of New Brunswick, Fredericton, Canada
x1571629674@gmail.com

Abstract. The United States has the strongest information industry in the world. It is the world leader in the number of invention patents in information technology filed. This is closely related with its Information Technology Education through its entire educational process. This also led to the rising income inequality in the country. This paper establishes a general equilibrium model based on the framework of skill-biased technical change to illustrate that the rapid development and application of IT industry is the main source of rising income inequality in the United States.

Keywords: Information Technology Education · Application and Development · Impact

1 Introduction

The United States is the birthplace of global information technology. In the past half century, American enterprises, governments and scientific research institutions have joined hands with each other to lead the development process of global information technology. In the IT field, the United States is undoubtedly the most technically powerful country. Former US President Barack Obama once said boldly, "If we want to fight a cyber war, I promise that if we want to win, we will win." The strong power in IT filed is closely related with its information technology education in U.S.A. The United States is the country with the earliest start of information technology education in the world. Since the mid-1960s, the Massachusetts Institute of Technology has been conducting a LOGO language teaching experiment with young children.

This paper establishes a general equilibrium model based on the framework of skill-biased technical change to illustrate that development and application of information technology is the main source of rising income inequality in the United States.

2 Information Technology Education in the United States

2.1 Information Technology Education in Primary School

The United States is the country with the earliest information technology education in the world. In the 1990s, the United States paid more attention to computer education in primary and secondary schools. Primary school computer education requires

X. Yuan et al. (Eds.): ICEKIM 2023, AHCS 13, pp. 1718–1723, 2023.
https://doi.org/10.2991/978-94-6463-172-2_189

pupils to "initially understand the importance of the application functions and computing techniques of computers, and to operate them simply on computers or other electronic devices". Middle school is the learning stage of "computer science", which includes computer programs, algorithms, data structure, data extraction and so on [1]. Successive governments in the United States have committed to improving the level of primary education in science, technology, engineering and mathematics (STEM). In 2001, the federal government of the United States promulgated the famous No Child Left Behind Act, which made it compulsory for all students in grades 3 to 8 and all high school students to take standardized tests in science, reading and mathematics. All state and local governments are required to track the teaching progress of all public schools in the state every year, check the rationality of their annual progress standards, and achieve the goal of improving students' substantive educational output and academic quality by establishing institutionalized national policies [2].

After that, the Obama government set a grand national goal to continue to promote the STEM level of basic education in the United States [3]. It gave priority to STEM education in the comprehensive education reform of the United States, so that most American children's science and mathematics test scores rose from the middle of the international rankings to the top, and prepare 100,000 excellent STEM teachers and more than 1 million university students within 10 years. During 2008 economic crisis, the Obama federal government introduced "Race to the Top" competitive funding program under the circumstance of reduced education expenditure, in which the science and technology discipline (STEM) was included in the main evaluation criteria. They strengthened the goal of improving the performance of American students in science and technology (STEM) through the financial allocation system.

2.2 Information Technology Education in the Universities

American universities students have a preliminary understanding of the background of information exchange through some basic courses. On this basis, they learn the practice of people interacting with information through more differentiated and targeted courses. The basic courses include data analysis, database management, programming, communications and technology [4].

Information science students mainly study design and management of complex information systems, and pay much attention to the application of information systems. Among them, the convergence of information science, technology and management are the main concerns. In addition, students are required to take courses in probabilistic, statistics, and operational modeling techniques. At the same time, there are also management direction courses, which teach students to master the method of quantitative decision-making and its application in information technology, as well as the effective control methods of information technology. Students are also required to attend advanced mathematical modeling courses in Management Science, Information Systems, IT Mathematical Modeling, and Information Technology Management solutions.

The information science programs of American universities focus on the combination of theory and practice, and students have the opportunity to conduct experiential learning in museums, libraries, schools, enterprises, cultural institutions, archives and

Table 1. Changes in the indexed value of the 90th and 10th percentiles of the disposable income distribution for working population aged 18- 65 in the United States

2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
5.7	5.8	6.1	6.2	6.2	6.4	6.4	6.2	6.2	6.1	6.1	6.1

Data sources: https://stats.oecd.org.

other institutions in different regions. Students can choose courses and internship programs in a planned and targeted way according to their career goals. The research and practice of information science are committed to synchronize with the rapidly changing technology.

3 The Impact of Information Technology Education on Income Inequity

Education is one of the important factors that cause income inequality [5]. It is an important channel to obtain human capital. The Gini coefficient is an important index to comprehensively measure income inequity among residents. The coefficient is between 0 and 1, and the larger the value, the greater the income gap between residents. It usually takes 0.4 as the "warning line" of the income distribution gap. The US Gini coefficient has been above the "warning line" of 0.4 over the past two decades [6]. That means the income inequity in the United State is very big compared to other countries in the world.

Furthermore, P90/P50, P90/P10 and P50/P10 ratio of income can structurally reflect the gap between rich and poor, in which P90 is the ninth decile, that is, the top 10% of the highest income group, P50 represents the median of income group, and P10 is the lowest 10% of income group. The P90/P10 ratio reflects the income gap between the highest and lowest group. The US disposable income gap between the top 10% and the lowest 10% continues to widen after 2008, though eased in recent years.

As can be seen from Table 1, the p90/p10 ratio continues to increase in the United States from 5.7 in 2008 to 6.4 in 2013, indicating that the gap between high-income and low-income people in the United States is increasing. This is closely related to the information technology education and IT industry expansion in the country.

4 An Empirical Test of Impact of It Education on Income Inequality

Assuming that the educational level of workers is the equivalent measure of their technical level, the income gap of workers with different educational levels is the income gap of workers with different technical levels. Assuming that there are high-skilled workers (college students) and low-skilled workers (non-college students) in the market, the proportion of which is α and $1 - \alpha$ respectively, and the income of college students and non-college students is y^c and y^{nc} respectively. Under this assumption, the average income in the labor market is

$$E(y) = \alpha y^c + 1 - \alpha y^{nc} \tag{1}$$

The income inequality of workers is measured by the variance:

$$\begin{aligned} var(y) &= \left(y^2\right) - \left[E(y)\right]^2 = \alpha(1-\alpha)(y^c - y^{nc})^2 \\ &= (y^{nc})^2\alpha(1-\alpha)(y^c/y^{nc} - 1)^2 \end{aligned} \tag{2}$$

It can be obtained from the formula (2):

$$\partial var(y)/\partial\alpha = (1-2\alpha)(y^{nc})^2\left(y^c/y^{nc} - 1\right)^2 > 0 \cdot (\alpha < 0.5) \tag{3}$$

$$\partial var(y)/\partial\left(y^c/y^{nc}\right) = 2\left(y^{nc}\right)^2\alpha(1-\alpha)\left(y^c/y^{nc} - 1\right) > 0 \tag{4}$$

The conclusions of Eqs. (3) and (4) are the characteristics of the US income data: the proportion of high-skilled workers increases (but still less than 50%), and the relative income gap between the two types of workers widened, thus increasing the income inequality among the labor group.

Suppose the production function of the manufacturer in the economy is the CES form:

$$Y = \left[(A_l(\tau)L)^\rho + (A_h(\tau)H)^\rho\right]^{1/\rho} \cdot (0 < \rho \leq 1) \tag{5}$$

Among them, Y is the output, L is the low skill labor input, H is the high skill labor input. $A_l(\tau)$ and $A_h(\tau)$ represents the unit technical return rate of the low skill and high skill labor respectively, τ represents exogenous technical level and satisfies the following:

$$\partial A_l(\tau)/\partial\tau > 0, \quad \partial A_h(\tau)/\partial\tau > 0$$

Make $\sigma \equiv 1/(1\text{-}\rho)$, the substitution elasticity between high- skilled and low- skilled labor.

The production of the manufacturer meets the optimal first-order conditions, from which the unit wage of the two types of labor force is respectively:

$$w_l = A_l^\rho(\tau).L^{\rho-1}.[(A_l(\tau)L)^\rho + A_h(\tau)H)^\rho]^{\rho-1} \tag{6}$$

$$w_h = A_h^\rho(\tau).H^{\rho-1}.[(A_l(\tau)L)^\rho + A_h(\tau)H)^\rho]^{\boldsymbol{\rho}-1} \tag{7}$$

The mechanism of skill-biased technological advances to increase income inequality in the labor market can be derived from the following process:

$$r_w \equiv w_l/w_h = [A_l(\tau)/A_h(\tau)]^\rho(\frac{H}{L})^{1-\rho} \tag{8}$$

Take the logarithm of formula (8)

$$\ln(r_w) \equiv \ln(w_l/w_h) = \rho\ln[A_l(\tau)/A_h(\tau)] + (1-\rho)\ln H/L \tag{9}$$

Equation (9) derivate τ on both sides simultaneously:

$$\frac{\partial ln(r_w)}{\partial\tau} = \frac{1}{r_w}\cdot\frac{\partial r_w}{\partial\tau} = \rho\frac{A_h}{A_l}\frac{\partial\left(\frac{A_l}{A_h}\right)}{\partial\tau} + (1-\rho)\frac{\partial r_w}{\partial\tau}\left[\frac{\left(\frac{\partial H^s}{\partial r_w}\right)}{H} - \frac{\left(\frac{\partial L^s}{\partial r_w}\right)}{L}\right] \tag{10}$$

Labor market clearing, H = H^s L = L^s, further sorting out to get:

$$\left[\underset{+}{\frac{HL}{r_w}} - (1-\rho)L\underset{-}{\overset{+}{\frac{\partial H^s}{\partial r_w}}} + (1-\rho)H\underset{+}{\frac{\partial L^s}{\partial r_w}}\right]\cdot\frac{\partial r_w}{\partial\tau} = HL\,\rho\underset{+}{\frac{A_h}{A_l}}\cdot\underset{-}{\frac{\partial(A_l/A_h)}{\partial\tau}} \tag{11}$$

Obviously, $\frac{\partial r_w}{\partial\tau}<0$, this suggests that with technological advances (τ rising), the relative income of less skilled workers decreases (r_w declines), inequality in the labor market has risen. On this basis, the impact of skill-biased technological progress on the relative supply of the two types of labor force can be further obtained.

$$\partial H/L/\partial\tau = \left[\overset{-}{\left(\partial H^s/\partial r_w\right)}\,\overset{-}{(\partial r_w/\partial\tau)}\,L - \overset{+}{\left(\partial L^s/\partial r_w\right)}\,\overset{-}{(\partial r_w/\partial\tau)}\,H\right]/L^2 > 0 \tag{12}$$

So far, two characteristics reflected by American labor force data are obtained from the model: (1) the relative wage of high-skilled labor increases and the income gap increases [6]; (2) the relative supply of high-tech labor increases [7].

5 Conclusions

The rapid development of information technology has penetrated into all aspects of economic and social life, and it has also brought about profound changes in the labor market [8]. As early as 1998, the US Department of Commerce released a special report on the digital economy, pointing out that the development of information technology, the Internet and e-commerce will lead to new forms of the digital economy. Over the past 15 years, the US digital economy has been booming, with an average annual growth rate of more than 6%, three times that of the overall economy. The digital divide will create unequal inequality in education and employment, further increasing income and wealth inequality in the United States and widening gap between rich and poor people [9]. This will be an urgent problem for the United States to solve in the process of the digital transformation of the economy.

References

1. Ding Jing. "Current status of k-12 computer education in America and its enlightenment for information technology education in China" [J]. Information Technology Education in Primary and secondary schools, 2015 (11): 34–37.
2. Lu Jinjiao, Liu Meifeng, Shi Lifan. "A Historical Review of the Application of Information Technology Education in the United States: Expected influence and realistic influence [J]. Electrochemical Education Research, 2022, 43(11):115–121+128.

3. Li Feng, Wang Jiqing. An Analysis of the Objective Orientation of Information Technology Education in Contemporary American Primary and Secondary Schools [j]. Research on Audio-visual Education, 2013,34 (12): 102–107.
4. Macleod W B, Urquiola M, "Why Does the U.S. Have the Best Research Universities? Incentives, Resources, and Virtuous Circles", NBER Working Paper 28279, 2020.
5. Acemoglu, D. (2002). Technical change, inequality, and the labor market. Journal of economic literature, 40(1), 7–72
6. Xu Shu. Technological progress, educational gains, and income inequality [J]. Economic Research, 2010,45(09):79–92+108.
7. Acemoglu, Daron, "Why Do New Technologies Complement Skills? Directed Technical Change and Wage Inequality" Quarterly Journal of Economics, 113 (1998), 1055–1090.
8. Acemoglu, Daron "Changes in Unemployment and Wage Inequality: An Alternative Theory and Some Evidence" American Economic Review, 89(1999a), 1259–1278.
9. Aghion, Philippe, "Technical Change, Institutions, and the Dynamics of Inequality" mimeo, (2000).