Bilateral Relationship between Technological Changes and Income Inequality in Developing Countries

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Abstract

The work focuses on the analysis of the bilateral relationship between technological changes and inequality. First, it focus on the impact of technological innovations on inequality and the theory of Skills Biased Technological Changes (SBTC). Given technology can produce inequality; what is the impact of these inequalities on the distribution and the production technologies? Conversely, it´s interested in, the transmission channels through which inequality affect technological changes. And that being said, let's enrich the interactions between inequality and technological changes. The empirical validation is based on the technique of Panel data for a sample of developing countries. The paper concludes that a positive relationship of technological changes on inequality seems to be confirmed. Increased innovation increases inequality. And a negative effect of inequality on technological changes also seems to be confirmed. Rising inequality hampers technological innovations.

Resumen

El trabajo se centra en el análisis de la relación bilateral entre los cambios tecnológicos y la desigualdad. En primer lugar, se enfoca en el impacto de las innovaciones tecnológicas en la desigualdad y la teoría de las habilidades sesgadas por cambios tecnológicos. Dado que la tecnología puede producir la desigualdad; ¿cuál es el impacto de estas desigualdades sobre la distribución y las tecnologías de producción? Por el contrario, interesan los canales de transmisión a través de los cuales la desigualdad afecta a los cambios tecnológicos. Y dicho esto, se enriquezcan las interacciones entre la desigualdad y los cambios tecnológicos. La validación empírica se basa en la técnica de datos de panel para una muestra de países en desarrollo. El trabajo concluye que una relación positiva de los cambios tecnológicos sobre la desigualdad parece ser confirmada. El aumento de la innovación aumenta la desigualdad. Y que un efecto negativo de la desigualdad en los cambios tecnológicos también parece confirmarse. La desigualdad creciente obstaculiza las innovaciones tecnológicas.

Keywords: Technological changes, inequality, developing countries.

JEL Classification: O32, O34, D31.

1. Introduction

In recent decades it have witnessed in developed countries an accelerated increase in income inequalities especially at the top of the income scale: «the top 1%» has seen its share in total income rise quickly (Goldin and Katz, 2008; Deaton, 2013; Piketty, 2013). Aghion, Akcigit, Bergeaud, Blundell, and Hemous, (2015) used data on production and quality of patent and data on income distribution in different United States during the 1975-2010 period to demonstrate that innovation is one of the key factors of this increase in inequality at the top of the scale (top inequalities).

The underlying assumption is that the adoption of New Technologies requires a high level of human capital, which is often scarce from process technology diffusion. Given this scarcity, it notices an increase in the wages of skilled workers, while the wages of the remaining workers are maintained at their original level or decrease, resulting in inequality in wages.

The proliferation of New Technologies confirms the questioning of the positive role of technology in economic growth and wealth distribution. Technology therefore acts as a factor in increasing inequality (Aghion and Howitt, 1998; Galor and Moav, 2000). The explanation of these authors is often the technological bias. Technical innovation is explained by intensive technical qualifications, which increase demand for more skilled labor, thus digging the income gap between workers. Because of the complementarity between technology and labor input, we are witnessing a factor complementarity between technology and skilled labor.

Since technology can produce inequality, it can ask if inequality can conversely prevent the diffusion of technology. The economic literature that studies the sense of causality is still too limited. Therefore, the work to implement an enrichment of this research is at the center of a new debate on the facts of inequalities in the distribution of New Technologies. By focusing on the relationship that may exist between technological changes and inequality, interest is twofold: (i) to verify the hypothesis of SBTC and study the impact of technological changes on inequality and (ii) to study the impact of income inequality on technological changes.

2. Literature review

Technological changes favor more skilled workers; replace the tasks previously performed by unskilled labor, and increases inequality. This vision is formed on the basis of decades of experience, which witnessed major changes in technology, including the rapid spread of computers in the workplace and in our lives, and also including wage inequality. In the United States, for example, the premium for the university - the salaries of university graduates compared to the wages of nonuniversity graduates - rose by more than 25 percent between 1979 and 1995. The overall income inequality also rose sharply. In 1971, a worker at the 90th percentile of the wage distribution earned 266 percent more than a worker at the 10th percentile. In 1995 this number reached 366 percent (Acemoglu, 2002).

Several researchers found a direct causal relationship between these radical technological developments and changes in the distribution of wages in the US economy. The title of the article by Krueger (1993): «How computers have changed the pay structure» on computers and inequality summarizes this view. Greenwood and Yorukoglu (1997) also give the following brief report: the installation and operation of the new technologies often involve the acquisition and processing of information. Competence facilitates this adoption process. Therefore, periods of rapid technological advancements should be associated with the skill performance. They argue that we are now in the midst of a «third industrial revolution» fueled by advances from the information technology revolution which is responsible for the increase of inequality.

In recent decades, the United States and many OECD countries have shown experienced fundamental changes in wage inequality between skilled labor and less-skilled labor. Most empirical studies focus on the United States. Wage inequality has increased steadily in the United States from the early 70s. The report of the weekly wages of richest compared to poorest increased by 35% between1965-1995 (Katz and Autor, 1999). The average and median wages have remained constant in real terms since the mid 70s. Real wages at in the bottom of the wage distribution decreased significantly. For example, the 10th percentile of wages decreased in real terms by 30% from 1970 to 1990 (Acemoglu, 2002). On the contrary, wages at the top of the wage distribution scale increased rapidly.

Much of the absolute increase in higher wages is associated with a surge in CEO compensation. Piketty and Saez (2003) show that in 1970, the salary of the top 100 CEOs in the United States was about 40 times larger than the average wage. In 2000, these CEOs earned nearly 1000 times the average wage. The annual performance of the university level (relative to secondary level) was 33% in the 80 and over 50% in the 90 (Eckstein and Nagypal, 2004). Yields manual trades for the professional trades and intellectuals show a similar dynamic to the data stratified by education. For example, the premium for the blue-collar occupation increased by 20% from 1970 to 1995 (Eckstein and Nagypal, 2004).

The above above-mentioned phenomena have attracted much academic attention and several explanations, including the effects of Skills Biased Technological Changes -SBTC (Krueger, 1993; Acemoglu, 1998; Card and DiNardo, 2002; Aghion et al., 2015). The rapid increase in the university premium in the 80s is due to SBTC. According to this explanation, New Technologies are, by their nature, complementary with skills. So there is always some SBTC and the recent past has witnessed the rapid introduction of New Technologies, leading to an acceleration of biased skills. The SBTC hypothesis is confirmed by estimating the equations, which link the shares of the employment of the non-manual workers, on the one hand, and the expenditure in R&D and in the use of the computers, on the other hand.

The salary model of inequality over the past 30 years differs substantially across countries. The British economy has seen an increase in wage inequality similar to that of the United States economy. Continental European countries have seen virtually no change in wage inequality, whereas during the same period they have had large increases in their unemployment rates. Instead, the United States unemployment rate and the labor share remained relatively constant (Blanchard and Wolfers, 2000). So, what is the fate of developing countries? And conversely, what is the impact of inequality on technological changes?

An unequal distribution of resources impedes technological changes and growth because it prevents the formation of a middle class which, being an important source of purchasing power, can stimulate domestic production (Murphy, Shleifer and Vishny, 1989; Jaramillo, 1995; Bertola, Foellmi and Zweimüller, 2006). As for domestic demand, with inequitable distribution, an employee whose income is relatively low compared to that of a capitalist often requires wage goods at low prices while a capitalist often demands imported luxury goods. Indeed, since rich and poor consumers buy heterogeneous consumer goods of different values, the initial level of income inequality determines the effective supply of the future structure. Thus, the initial distribution of national income can also affect the long-term growth rates by changing the size and composition of the final domestic demand.

This mechanism, which is on the side of the demand, shows the role of the composition of domestic demand on the onset of the process of industrialization of the developing countries. According to this approach, the limited size of the local market is a major constraint to the principle of industrialization. Low incentive to invest in poor countries is mainly attributed to the limited size of the local demand to produce quite large markets for local industries. A great initial push that contributes to the simultaneous production of several complementary sectors is needed to break the vicious circle of underdevelopment.

The existing theoretical models yield very different predictions regarding the impact of a greater inequality on the level of R&D investment, and hence, on technological changes depending on whether one considers process or product innovation (Foellmi, Wuergler and Zweimüller, 2014). The predictions are different depending on whether one considers the introduction of new goods, a new variety of existing goods (horizontal differentiation), or a new quality of an existing good (vertical differentiation). Thus, the notion of non-homothetic preferences includes several types. Consumers may express preferences over goods produced by different industries (luxury vs. first necessity goods) (Murphy et al., 1989; Jaramillo, 1995), or different horizontally differentiated varieties of goods belonging to the same industry (Foellmi and Zweimüller, 2006), or different quality-differentiated versions of the same products (Latzer, 2013). The differences existing between these different types of hierarchic consumption are crucial regarding the nature of the impact of varying degrees of inequality since the competition structures (and the resulting pricing of firms as well as expected profits following innovation) strongly differ across the different model types.

The demand for consumers, where the distribution is very uneven, generates a negative effect on the production and the economic growth. Moreover, knowing that goods are produced with a technology with increasing returns without sufficient domestic demand, producers are unable to sell these goods and cover their fixed costs. Murphy et al. (1989) were conscious that if the international trade were free, the size of the domestic market would be of no relevance. However, they have argued that the transport costs, the difficulties in foreign markets and the trade barriers make the domestic demand particularly important to stimulate domestic growth. Besides, since access to global markets is difficult for a developing country, the degree of industrialization (the extent of the variety of goods is produced using modern technologies) strongly depends on the size of domestic markets, which is influenced by the income distribution in the country.

Jaramillo (1995) has shown that a more equal income distribution positively influences the growth rate in the long-term, causing an increase in the number of employed workers in the modern sector and an expansion of domestic markets for goods production. These results suggest that the redistribution of income of the upper class to the middle class should stimulate the industrialization of the developing countries by increasing the size of their domestic markets. This has the effect of homogenizing the domestic demand for industrial goods, which results in the creation of markets for a large number of goods produced using modern technologies. So, what is the impact of inequality on technological changes for our sample of developing countries?

3. Empirical analysis

3.1. Model and data

The work estimates in a first equation the inequality based on technological changes, income, human capital and investment price. It also evaluates in a second equation technological changes in line with inequality, income, human capital and the investment price. The following model has been used.

$$lINEQ_{i,t} = \alpha_i + \beta_1 lTC_{i,t-1} + \beta_2 lI_{i,t-1} + \beta_3 PE_{i,t-1} + \beta_4 SE_{i,t-1} + \beta_5 HE_{i,t-1} + \beta_6 lIP_{i,t-1} + \mu_{i,t} \quad (1)$$

$$lTC_{i,t} = \alpha_i + \beta_1 lINEQ_{i,t-1} + \beta_2 lI_{i,t-1} + \beta_3 PE_{i,t-1} + \beta_4 SE_{i,t-1} + \beta_5 HE_{i,t-1} + \beta_6 lIP_{i,t-1} + \mu_{i,t} \quad (2)$$

which «i» represents each country and «t» represents each time period (t = 1, 2, ...T). «INEQ» (inequality) is taken from the World Institute for Development Economics Research (WIDER, 2014). «TC» (technological changes) is measured by the number of patents filed by residents and non-residents. Technological changes are taken from World Intellectual Property Organization (WIPO, 2010). This variable is measured by the Gini coefficient. «I» income is obtained from version 7.1 of the Penn World Tables (Heston, Summers and Aten, 2012), knowing that it is measured by the real GDP per capita. Human capital statistics are represented by the average years of «PE» (primary education), «SE» (secondary education) and «HE» (higher education) and come from the database of the Educational Attainment International Data: Updates and Implications (Barro and Lee, 2013). «IP» (investment price) is also taken from the Penn World Tables (Heston et al., 2012). «μ» is the error term. The variables on technological changes, inequality, income and investment price are expressed in logarithm.

The model focuses on inequality and technological changes for a homogeneous sample of 19 developing countries for the period from 1965 to 2010. The list of countries includes: Bangladesh, Bulgaria, Chile, China, Colombia, Costa Rica, Czech Republic, Ecuador, Estonia, India, Indonesia, Jordan, Moldova, Pakistan, Peru, Philippines, Romania, Sri Lanka and Thailand. The Panel is unbalanced; that is to say, it does not have the same number of observations in the time dimension for all the countries.

3.2. Estimation

It begins to test the hypothesis of a perfectly homogeneous structure (identical constant and slope). If the Fisher statistics associated with the total homogeneity test are greater than the Fischer statistical table, therefore it rejects this hypothesis. In this case, it finds that for both equations, the Fisher statistic obtained is superior to that of the statistical table. This leads to conclude that it must reject the null hypothesis of inter-individual homogeneity. In other words, it must favor a model taking into account individual specificities.

To study the stationarity of the variables, it use the IPS (Im, Pesaran and Shin, 2003), which is based on the well-known Dickey-Fuller procedure. Im, Pesaran and Shin denoted IPS proposed a test for the presence of unit roots in Panel that combine information from the time series dimension with that from the cross-section dimension so that fewer time observations are required for the test to have power. Since the IPS test has been found to have superior test power by researchers in economics to analyze long-term relationships in Panel data, it will also employ this procedure in this study. All variables used show non-stationarity. To determine the order of integration series; we apply the IPS test for the series of the first order differences. It can observe that the series become stationary and these non-stationary variables are integrated of order one (I (1)).

3.3 Results and discussion

The sources and the detailed definitions of all variables are shown in Table 1 with mean, standard deviation, minimum and maximum.

Table 1: Summary of Statistics

Variable	Measure	Source	Mean	Standard Deviation	Minimum	Maximum
Inequality	Log of GINI coefficient.	World Institute for Development Economics Research (WIDER, 2014).	1.751	0.321	1.124	1.981
Technological Changes	Log of the number of patents filed by residents and non-residents.	World Intelectual Property Organisation (WIPO, 2010).	2.657	0.654	0.301	5.115
Income	Log of real GDP per capita.	The Penn World Tables (Heston, Summers and Aten, 2012).	8.948	0.687	6.983	10.369
Primary Education	Average years of primary schooling in population aged over 15.	A New Data Set of Educational Attainment in the World, 1950-2010 (Barro and Lee, 2013).	4.987	1.987	0.345	8.713
Secondary Education	Average years of secondary schooling in population aged over 15.	A New Data Set of Educational Attainment in the World, 1950-2010 (Barro and Lee, 2013).	1.125	1.417	0.158	5.862
Higher Education	Average years of higher schooling in population aged over 15.	A New Data Set of Educational Attainment in the World, 1950-2010 (Barro and Lee, 2013).	0.347	0.124	0.007	1.095
IP	Log of price level of investment.	The Penn World Tables (Heston, Summers and Aten, 2012).	1.457	0.203	1.236	2.498

Source: Compiled by the author.

The estimated equations reveal the presence of delayed dependent variables, which are a major problem. This complication originates from the correlation between the dependent variable delay and disruption, although «μ_{it}» is supposed to be uncorrelated. Thus, Blundell and Bond (1998) proposed a GMM model system, which consists of a model equation in first difference and an equation of the initial level model. The convergence of the estimator of the GMM is determined by the validity of the instruments given by the lagged values of the explanatory variables. Two tests are associated with the GMM dynamic Panel: the over-identification test of Sargan/Hansen, which can test the validity of the lagged variables as instruments, and the autocorrelation test of Arellano and Bond where the null hypothesis means the absence of autocorrelation of the first order errors in the level equation. In the regressions, the results of both tests are in line with expectations. Indeed, the statistics do not reject the Ho hypothesis of the validity of the lagged variables as instruments. The instrumental variables are not correlated asymptotically with the disturbances of the estimated model, and the selected instruments are valid. The estimation results are reported in Table 2.

Table 2: Results of the Estimation

Estimation of equation (1)	Sys-GMM	Estimation of equation (2)	Sys-GMM
TC	0.3654*** (0.003)	INEQ	-0.6547** (0.014)
I	0.1578** (0.025)	I	0.5687** (0.025)
PE	0.8795 (0.589)	PE	0.0321 (0.254)
SE	0.8213** (0.048)	SE	0.6258** (0.034)
HE	0.1785** (0.023)	HE	0.8974*** (0.000)
IP	0.2658** (0.019)	IP	-0.5698** (0.012)
Countries	19 countries	Countries	19 countries

Note: *, **, *** denotes significance at 10%, 5%, 1%; the values in parentheses represent probabilities.

Source: Compiled by the author.

In equation 1, the income coefficient is positive and significant. An increase in national income increases inequality. This can be explained by the uneven distribution of the fruits of growth among individuals in developing countries. It also finds a positive and significant effect of primary education, a positive and significant effect of secondary education and a positive and significant effect of higher education on inequality. It can say that an increase in secondary and higher education positively influences inequality. The increase in qualifications and skills thus increases income inequality because of the wage gap between educated individuals and uneducated ones.

The price of the investment coefficient is positive and significant. An increase in the price of investment leads to an increase in inequality due to unequal access by individuals to finance. It's the idea that it only lends to the rich. Finally, the coefficient of technological changes is positive and highly significant. Technology therefore plays a crucial role in determining inequality. A positive relationship between inequality and technological changes may be confirmed for a sample of developing countries. An increase of technological changes of 1 point is correlated with an increase of 0.3654 in inequality. This confirms the thesis of SBTC.

Turning to the equation 2, the income coefficient is positive and significant for technological changes. There is a positive relationship between income and the technological changes. An increase in income enhances technological changes. It found a positive and non-significant effect of primary education on technological changes and a positive and significant impact of secondary education on technological changes. Besides, higher education has a positive and highly significant influence on technological changes. This makes it say that an educated and skilled human capital positively affects technological changes. This allows saying that the most educated human capital affects technological innovations. The most educated individuals subsequently become innovators.

Besides, the price of the investment coefficient is negative and significant. An increase in the price of investment affects innovation investments negatively. This fall in investment and innovations discourages technological changes. The coefficient on inequality is negative and significant. Therefore inequality plays a crucial role in determining technology. A negative relationship between inequality and technological changes can be confirmed for a sample of developing countries. Thus, Inequality represents an obstacle to technological progress. An increase by 1 point in inequality is correlated with a decrease in technological changes of 0.6547.

Finally, it can say that even if there are differences in the factors that might explain the links between inequality and technological changes, one fact remains, which is that most authors recognize that inequality is a source of inefficiency. Therefore, policies should be put in place to combat these factors. They are needed both to make the system fairer and help stimulate economic growth.

Moreover, for the impact of technological changes on inequality, Berman and Machin (2000), Conte and Vivarelli (2007), Saafi and Sboui (2012) and Ben slama and Plassard (2011) confirmed the SBTC hypothesis using the technique of Panel data. Conte and Vivarelli (2007) represented the technological changes by importing technologies. For Berman and Machin (2000), technology indicators are the use of computer and R&D. These two studies were interested in a sample of developing countries. On the other hand, Saafi and Sboui (2012) were interested in 9 industrial sectors in Tunisia. These authors found that technological diffusion leads to a change in the structure of employment in favor of skilled workers. They also found that increasing the technological value raises the demand for skilled labor and reduces the demand for unskilled labor and that the capital increase is correlated with the increase of the demand for skilled labor. In another study on Tunisia and in the framework of an Alliance for Research on North Africa (ARENA), Iwasaki and Kashiwagi (2011) clarifies the relationship between human capital and employment in Tunisia, estimating the education performance on work and salary. Taking into account regional differences of the surveyed regions (Kebili, Monastir, Beja and Tataouine), the results of their analysis confirm the positive impact of investment in education on productivity and labor income. The level of education gives a positive return on household income.

For the impact of technological changes on inequality, Weinhold and Nair-Reichert (2009), their study has examined whether the presence of a well-developed middle class and intellectual property rights stimulate innovation for a sample of 53 heterogeneous countries. For them, this mechanism could be twofold: first, a large middle class could have an impact on the institutions, including intellectual property rights, which could in turn affect innovation. Second, the data taken from the economic history of the United States suggest direct links between the share of the middle class and the innovation through the effects of supply and demand. They have found that there are several plausible mechanisms through which inequality could be linked to innovation (the participation and the structure of market demand) having differential effects on the innovation of residents and non-residents and on the patenting activity. In particular, if the channel is through the increasing participation of the market, this increases the domestic innovation, but not necessarily the patenting of non-residents. If the channel is through the structure of demand, there may be incentives for innovators residents and non-residents to classify domestic patents.

Bertola et al. (2006) have examined whether a more equal distribution of income is beneficial for growth or not; this depends crucially on the existence of substitute goods for the innovative goods. For them, too, there exist two effects. On the one hand, the distribution of income has an effect on the size of the market. High inequality results in a limited market, growing very slowly, for the new goods. The effect of market size implies that a more equal distribution of income is conducive to innovation and growth (Bertola et al., 2005). On the other hand, there is a price effect. A very unequal distribution implies that the richest consumers have a high willingness to pay for innovative goods. The price effect implies that inequality tends to be beneficial for the growth, because profit margins become higher in the early stages of the product's life cycle. However, the dominance of the price effect on the effect size of the market depends on the innovator's price level. If the new goods are competing goods that meet the same needs, the size of the market of an innovator will also be reduced and the effect of market size will dominate. If the innovators open new opportunities for consumption, their market power will be great and the rich consumers will be eager to pay very high prices. Under such conditions, the price effect will dominate, and inequality can be beneficial to growth.

For Foellmi et al. (2014) and from the point of view of consumption, if the newly created products are expensive then the new technologies can be tangible for the wealthy segment of the population. Inequality arises in this case as a factor facilitating the dissemination of the new technologies (Galbraith 1998). When they reach maturity, the prices of new technologies decline and their use becomes widespread. Inequality, which has been a condition for the introduction and dissemination of new technologies initially, will eventually end up slow starting from a certain threshold. Such explanations suggest to us the existence of a threshold from which we will observe a reversal of the effect of inequality on technology (Mani, 2001; Zweimüller, 2000; Foellmi et al., 2014).

4. Conclusion

It explained the theory of SBTC and the hypothesis of complementarity between technology and skills or complementarity between capital and skilled labor. It presented the impact of technological innovations on inequality. Furthermore, it showed that technological changes result in inequality between skilled and unskilled workers. If technology can produce inequality, it has shown that these inequalities influence, in turn, technological broadcasts. The economic literature that studies the sense of causality is still too limited. Therefore, it worked for an enrichment of this research, which is the center of a new debate on the effects of inequality on the distribution of New Technologies. Finally, it confirmed a negative link between inequality and changes in technology.

Technological changes create social mobility. Indeed, it know that innovation is accompanied by «creative destruction», i.e. it implies permanent existing businesses with new activities, together with constantly new innovators that come to compete and dislodge the innovators of yesterday. In Sweden, the richest man is the inventor of Skype, which was unknown there fifteen years ago. While it is true that innovation advantage in the short term to those generated innovation, in the long term rents innovation dissipates because of imitation and creative destruction (the replacement with new innovations). That inequality, which is generated by innovation, is temporary. The link between innovations and creative destruction is that innovation generates social mobility. Aghion et al. (2015) show a strong positive correlation between innovation and social mobility measured by the probability for an individual from a modest background to reach the top of the scale (the top quintile) in 2010, the year when he reached adulthood.

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