Impact of Inequalities on Technological Changes: Case of the Developing Countries

Sirine MNIF
Affiliation Department of Economics, Faculty of Economic Sciences and Management of Sfax/ University of Rennes 2 - Haute Bretagne, Tunisia/France

DOI: 10.6007/IJARBSS/v5-i3/1532 URL: http://dx.doi.org/10.6007/IJARBSS/v5-i3/1532

Abstract: Technology necessarily produces inequality; we, then, ask whether inequality can block the dissemination and production of technologies. More specifically, we focus on the transmission channels through which inequality affects positively and negatively technological change. There is relatively little evidence concerning the impact of inequality of human capital on the rate of innovation. Economic literature that studies this direction of causality is still limited. However, our goal is to enrich this literature and study the impact of inequality on technological change. Econometrically, our study is based on the technique of unbalanced panel data. An estimate by the method of static panel seems more relevant and a negative effect of inequality on technological changes seems to be confirmed for 48 developing economies.
Keywords: Inequality, Technological Change, Local Market Size, Neo-Schumpeterian Approach
JEL Classification: D31, D40, O30

1. Introduction

Until recently, technology and inequality have been considered as two separate concepts. Technology has been seen as the engine of growth in developed countries, while inequality has been seen as a fundamental problem in developing and developed countries.

Acemoglu (2002) has pointed out that the emergence of the New Technologies has been accompanied by an increase in income inequality in the United States and England. Several empirical studies in the field of Information and Communication Technology have also confirmed a proliferation of income inequality in developed countries. The underlying assumption is that the adoption of New Technology requires a high level of human capital which is often scarce at the beginning of the process of technological diffusion. Given this scarcity, we are witnessing an increase in the wages of skilled labor while the wages of the rest of the workers are maintained at their initial level or they decreased, which leads to inequality in the wages.

If technology can produce inequality, we can ask whether inequality can also block the production of technologies. The economic literature which studies this relation of causality is still limited. Consequently, our work tries to make some contributions to this research axis which is at the center of a new debate about the effects of inequality on the distribution of the New Technologies. Exploring the link between inequality and technology diffusion in this direction, we suggest checking whether inequality can reduce the technological changes based on an econometric study. Almost all the empirical works focus on the developed countries. To remedy this shortcoming, this study use a panel comprising 48 developing countries, selected according to the availability of data over a period of 56 years. For this purpose, we present a review of the theoretical and empirical literature on this issue. After that, we outline our specified model and the data that we have used for the empirical validation. Finally, we compare some of the theoretical hypotheses using econometric tests on panel data to verify the impact of inequality on the technological changes for our sample of countries.

1. Literature review

A good deal of early studies on the relationship between income inequality and innovation has focused on the effects of the technological changes on wage inequality within an economy (Acemoglu, 2002; Aghion, 2002; Huw, 1999; Mendez, 2002). Relatively few studies have examined the inverse relation: the effect of inequality on innovation, although there is an extensive literature that deals with the market structure and the concentration of industry and their relationship with innovation. In the following section, we will study the impact of inequality on economic growth and innovation activities through market size. In addition, we will analyze the incentives of the demand based on innovation and the concept of non-homothetic preferences.

In the previous theoretical analysis of the connection between inequality and growth, the initial distribution of income affects the rate of accumulation of human and physical capital and the rate of long run growth by acting directly on the future supply of the factors of production. Let us suppose that all the agents consume homogeneous goods and the demand for produced goods has no impact on incentives to undertake profitable investments. However, it seems evident that the level of expected demand is a determinant reason behind the investment and innovation decisions made by the entrepreneurs. Indeed, since the rich and poor consumers buy heterogeneous goods having different values, the initial degree of income inequality determines the structure of the future effective supply. And, the initial distribution of national income can also affect the rate of growth in the long run by changing the size and composition of the final domestic demand.

This mechanism, which is on the side of demand, has received less attention in the recent literature about the link between inequality and growth. It is particularly shown by the name “balanced growth” (Nurkse, 1968; Rosenstein, 1943) approach which underlines the role played by the size and composition of domestic demand on the onset of the process of industrialization of the underdeveloped 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 level on R&D investment, and hence, on technological change depending on whether one considers process or product innovation (Zweimüller & Foellmi, 2009); even within product innovation, the predictions are different whether one considers the introduction of a new good, a new variety of an existing good (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, Schleifer & Vishny, 1989; Jaramillo, 1995), or different horizontally-differentiated varieties of goods belonging to the same industry (Zweimüller & Foellmi, 2006), or different quality-differentiated versions of the same products (Latzer, 2013). The differences existing between those 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.

To begin with, in their work, Murphy et al. (1989) have explicitly incorporated the distribution of income as a determining cause of the size and composition of local demand and consequently the potential for industrialization of developing countries. Their analysis focuses on the prospect of a poorly industrialized country. An unequal distribution of resources hampers the growth and the industrialization because it prevents the constitution of a middle class, which – being a source of significant purchasing power – stimulates the domestic production. As far as domestic demand is concerned, with an inequitable distribution, an employee whose income is relatively low compared with that of a capitalist, often demands low-priced goods; while, a capitalist demands luxury goods which often need to be imported, i.e., high export content.

Therefore, the demand for consumers, where the distribution is very uneven, generates a negative effect on the production and the economic growth. Moreover, knowing that the goods are produced with a technology with increasing returns without sufficient domestic demand, producers are unable to sell their goods and cover their fixed costs. Murphy et al. were conscious that if the international trade were free, the size of the domestic market would be of no relevance. But, 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 produced using modern technologies) strongly depends on the size of domestic markets, which is influenced by the income distribution in the country. The authors have considered a static model in which industrialization is at the beginning caused by an agricultural innovation and strong export growth that increases incomes and domestic demand for manufactured goods. However, for the industrial markets to develop, the distribution of income must induce a composition of the local demand where the purchasing power is concentrated in the hands of consumers of manufactured goods. The model implies that a redistribution of income which reduces inequality and increases the purchasing power of large sections of the population can be efficient because it stimulates domestic production, hence growth and industrialization.

Jaramillo (1995) has combined the static model of Murphy et al. (1989), in which the distribution of income determines the level of industrialization through the effects of market size, with a model of endogenous growth in which the rate of long run growth depends on the learning processes in industries that require modern production technologies. Unlike Murphy et al. (1989) who have studied only the positive effect of a decrease in initial income inequality on the level of production, Jaramillo (1995) has shown that a more equal income distribution influences positively the growth rate in the long run, causing an increase in the number of employed workers in the modern sector and an expansion of domestic markets for goods production.

More specifically, the expansion of the domestic industry depends on the number of local consumers who can afford manufactured goods. In fact, in this model, the consumers differ only in their income and they have identical preferences for consumer goods. When their income level increases, they expand the range of goods required instead of buying a larger quantity of the same goods they have already consumed (Ehrhart, 2009). Poor individuals consume only food that is produced using only technology with decreasing returns. Consumers of the middle class consume, next to food, some products manufactured using two alternative technologies according to the importance of the size of domestic markets. Rich people consume all the goods available in the economy.

Indeed, if a less unequal distribution of income leads to an increase in the size of local markets, so that, the implementation of modern technologies of production will prove to be profitable, employment in the modern sectors will increase and the training process will improve: labor productivity increases in all modern industries causing a fall in selling prices as well as an increase in the real demand of the modern products. Consequently, the increase in the number of workers in the modern sector boosts economic growth.

According to “Engel’s Law”, the consumption structure of an individual depends on the level of his income and the budget share of food decreases with this income. The German statistician Ernst Engel (1857) was the first who documented how the consumption patterns of individuals vary with the level of income. Plato has noted that: “The first and greatest need is food for the existence and life. The second is housing and the third is clothing”. Also Adam Smith wrote: “In addition to food, clothing and shelter are the two greatest needs of humanity” (Falkinger, 1994; Falkinger & Zweimüller, 1997). So, we talk about the hierarchical structure of demand. In other words, the success or failure of industrialization depends fundamentally on the distribution of income. The industrialization of a poor country can completely fail in the case of perfect equality or in the case of extreme inequality. In the first case, no consumer will be interested in the production (all the consumers buy food only) and no sector will be industrialized. In the second case, no modern technology (with increasing returns) can be implemented since the domestic market is not large enough to make it profitable.

These two results suggest that the redistribution of income of the upper class to the middle class should stimulate the industrialization of 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.

The previous models focus only on the impact of the income distribution on the rate of growth of the demand structure, without considering the feedback effect of the composition of demand on the distribution of income. However, with heterogeneous goods and the non-homothetic preferences (which take the form of a greater preference for the sophisticated goods, such as cars and computers, for higher income levels) in a model of distribution and growth with imperfect credit market, Mani (2001) has discussed how the interaction between income inequality and the structure of demand affects the accumulation and growth of human capital in a developing country.

Three categories of goods are produced using work with different skills: unskilled labor needed for necessities, workforce with medium skills for the simple manufactures and processing of high competence for more sophisticated manufactures. The demand for sophisticated goods by wealthy people leads therefore to a higher demand for skilled labor and a lower demand for less sophisticated goods by individuals of low and middle income. In addition, the acquisition of new skills requires an indivisible investment. The credit constraints make it difficult to obtain loans for education. Thus, the skill levels that consumers can achieve are limited by the richness and heritage of their parents. Taking into consideration that some poor people can afford a medium level of education, only wealthy individuals can acquire higher education.

In such a framework, the distribution of initial income determines not only the rate of long run growth through its effect on the demand for goods, but also the future distribution of income. An initially high income inequality results in the absence of a middle class. People are either too poor to consume the necessities or rich enough to buy luxurious goods. Accordingly, the relatively low demand for simple manufactures generates a relatively low demand for medium labor skill. This implies relatively low earnings for workers of medium skills who cannot afford a higher education, either. Besides, these employees cannot afford a higher education for their children, thus perpetuating a vicious circle of a high income inequality, a low human capital accumulation and a slow growth. On the other hand, a low initial income inequality is due to a large demand for simple manufactures on the part of the middle class and relatively high wage rates for workers with medium qualifications. Those employees, who have been too poor to invest in higher education for themselves, can make the same investment for their children. The medium skills level increases implying a higher growth rate and a more equal distribution of income in the long run.

Mani (2001) has also argued that the interaction between inequality and patterns of demand for goods is a potential source of persistent inequality. Firstly, with non-homothetic preferences, income distribution affects the pattern of demand for goods and services. Secondly, because of differences in intensities of factor of goods, this demand model also affects the distribution of the returns factor. A low initial inequality, through greater demand for less skilled labor, creates a vicious circle that moves families with low incomes and suffering from poverty to prosperity. However, under high initial inequality, lack of such demand corrupts this vicious cycle, resulting in a low accumulation of human capital and low growth.

The basic model of Bertola, Foellmi & Zweimüller (2005) also started from preferences characterized by a hierarchical spirit. In economic terms, the consumers with low incomes devote most of their spending to the basic needs. As incomes rise, people move towards needs having a lower priority. In terms of utility, the satisfaction of these lower priority needs gives a utility value which is lower than the satisfaction of the basic needs. Consequently, marginal utility decreases. It is obvious that the models of global consumption will depend on the distribution of income in such circumstances. For example, the demand for lower priority goods (luxurious) will be more important when there is a class of very rich people.

We will now move to another type of non-homotheticity: different horizontally-differentiated varieties of goods belonging to the same industry. The hierarchical structure of consumer demand also implies that the demand for new goods comes principally from relatively rich consumers and that demand for old goods is already saturated. The rate of long run growth changes positively with the increase in labor productivity that can occur in three sectors (production, imitation and innovation activities), like the composition of demand, which is determined by income distribution. Falkinger (1994) and Falkinger & Zweimüller (1997) have shown that the impact of inequality on growth can be positive or negative depending on the assumptions about the mechanisms driving the growth of labor productivity. If we assume that labor productivity is positively related to the diversity of products, a more unequal distribution of income stimulates the growth rate in the long run because of the positive relationship between income inequality and diversity of products.

Alternatively, if the growth of labor productivity is caused by an increase in average per capita income the rate of long run growth will be negatively related to income inequality. Since unequal distribution of income leads most of the time to a greater diversity of products and it does not result in an increase in labor productivity, more resources for innovation and imitation activities means little resources for the expansion of the production of consumer goods and thus a relatively lower growth rate in the long run.

So, it seems that, if innovation activities are the forces behind the endogenous long run growth, then the increase in wealth inequality increases economic growth and innovation activities since it induces a growing demand for new goods for relatively wealthy consumers. However, according to Zweimüller (2000a, 2000b), the redistribution of income from rich to very poor consumers promotes innovation activities and consequently growth by increasing demand for new goods. A decrease in the income for the very rich consumers has no impact on their demand for new goods: they are consumers of such goods after the redistribution. But very poor consumers become relatively richer and as a result buy innovative products.

Foellmi & Zweimüller (2006) have used the concept of “demand-induced innovation” to study the role of income inequality in an endogenous growth model. Rich consumers can meet more needs than poor ones. The prices and the market size for new goods and their evolution over time are determined by the distribution of income. Foellmi & Zweimüller (2006) have shown how a change in the distribution of income affects the incentive to be innovated and thus the long run growth.

Schmookler (1966) has emphasized the importance of the demand-induced innovation – the fact that an invention requires not only pre-existing knowledge, but also a sufficiently urgent want that consumers seek to fulfill. Demand-induced innovation has not received much attention in recent theories of innovation and growth. In these theories, it is generally assumed that every potential innovation is useful and the demand side plays a passive role.

Does man invent only when he can, so that the inventions that he makes in a certain period are essentially those which have become possible in the previous period? Or is it to man's wants with their different and changing intensities, and to economic phenomena associated with their satisfaction, so that one must primarily look for the explanation? In short, are inventions induced mainly through knowledge or through demand? (Schmookler, 1966).

Based on the Schmookler's concept of demand-induced innovation, Foellmi & Zweimüller (2006) have investigated how the distribution of income affects the process of innovation and long run growth. They are based on the fact that various requirements are not urgent and that they depend on the level of consumer income. The intensity of a particular need and changes over time, as economic growth increases the willingness of consumers to pay for this lack of satisfaction, will differ among consumers since the rich are willing to pay more than the poor.

How do inequalities affect the enticement to innovate? Assume there is less income inequality due to a lower relative income of rich to poor. This has two opposite effects on the enticements for innovation. On the one hand, such a redistribution of wealth reduces the motivation of the rich households to pay and the profits of innovators - because the new property is sold exclusively to the rich. On the other hand, such redistribution improves the situation of the poor and allows them to buy more goods. This has a positive effect on the profits of the innovators as the market of the new goods will grow faster into mass market. For Foellmi & Zweimüller (2006), the first effect always dominates the second. This is because profits increase at the end of a period: The flow of earnings declines across the life cycle of the product. The flow of profit is lower at the beginning of the life cycle and it increases later. Due to the updating, the first drop in profits exceeds the subsequent increase and the value of an innovation decreases. In short, because of the benefits at the end of the period, the decline in relative income has a negative effect on the motivation to innovate, which reduces growth.

When a more uniform distribution originates from a larger size of the rich population and each member of the wealthy group has a lower income (i.e., income becomes less concentrated in the hands of a few rich people at the expense of the others) such a change in the distribution affects the motivation to innovate thanks to the effect of market size and the price effect. The effect of the market size has a positive impact on the flow of profit because there are more people who buy the new goods. The price effect goes in the opposite direction. Since the willingness to pay for new goods decreases in accordance the richness of the class, innovators are forced to reduce the prices. The relative size of these two effects depends on the price set by the innovators. In the absence of suitable substitutes for innovative products, the price effect dominates the effect of the market size. However, if there are substitutes, the price suggested by the innovators will be more limited and the effect of market size will become dominant. A strong equality discourages innovative activities at the beginning and then promotes them later.

After that, we will focus on the latter type of non-homotheticity: different quality-differentiated versions of the same products. Latzer (2013) has presented a new rationale for the investment in R&D by incumbents, based on another stylized fact neglected in standard quality scale models: all scales of quality in high-tech sectors not only invest positive and significant amounts in R&D, but also produce and sell more than a differentiated quality version of their basic commodities. Indeed, Intel currently sells three different families of microprocessors, using different levels of speed and implementation; Microsoft commercializes Windows XP, Vista and Seven simultaneously; Nokia sells many mobile phones with differentiated qualities, showing significant variations in the functionalities offered. This device has been ignored by standard quality scale models, where homothetic preferences lead to the result that only the version of the commodity’s quality having the highest price is consumed in equilibrium. However, the opportunity to offer different packages of price-quality in order to distinguish between customers represents a significant motivation for the firms to invest in R&D in order to increase their range of products. Consequently, while so far the motivations for innovation by quality leaders have been argued to be mainly on the supply side (the cost benefits of the R&D leadership Stackelberg), Latzer (2013) has provided a product-conducted enticement conducted by the product for investment in R&D by incumbents.

Latzer (2013) based his view on endogenous growth models such as those of Li (2003), Zweimüller & Brunner (2005) and Zweimüller & Foellmi (2006), all allowing for more than one quality to be consumed at the equilibrium through differences in wealth endowment and non-homothetic preferences. In contrast, in the scale of standard quality (Grossman & Helpman, 1992; Segerstrom, Anant & Dinopoulos, 1990) models, the quality commodity is divisible and consumer preferences are homothetic, i.e., only the quality adjusted to the highest price will be consumed in equilibrium, even when differences in the endowments of wealth are taken into account: poorer consumers consume only a small share of the good quality products. Latzer (2013) has taken into account the level of consumer income to determine consumers’ willingness to pay for the highest quality. The economy is composed of two distinct groups of consumers, different in their endowment of wealth. This feature, associated with non-homothetic preferences, yields reports different possible market structures for quality goods at the equilibrium, depending on the extent of inequality in the distribution of wealth.

In order to analyze the model in equilibrium, Latzer (2013) constrained himself to the first case of a monopoly market structure for the sake of quality where the innovation race has been won by a challenger. It demonstrates the existence under certain parametric conditions of an interior solution for the steady state of equilibrium with positive R&D investment by the incumbent in the next innovative race. This result, then, allows us to study the effects of income inequality on the rates of innovation of the challengers and the incumbents, as well as on the rate of economic growth. Latzer (2013) showed that a growing population of poor always carries prejudice to the innovation rate, whereas income redistribution from rich to poor is beneficial to the innovation through the rates of challengers and it has ambiguous effects on innovation through the rates of the incumbents. So, he finally defined the equilibrium state for the case where the distribution of wealth induces a duopolistic market structure in the case where the final innovation race has been won by a challenger; and he proved that this case rarely occurs, taking into account the innovation by incumbents.

For Zweimüller & Foellmi (2009), they have been interested in the impact of a greater inequality level on R&D investment and hence technological change depending on whether one considers process or product innovation. They have shown how the growth process and the association between product and process innovation depend on the interaction between two major forces: the particular source of technical progress and the extent of economic inequality in a society. If technical progress is driven by product innovations, inequality will be beneficial for long run growth. The increase in inequalities allows innovators to charge high prices at the beginning of the period of innovation and during the subsequent period. When the new product enters into the mass market; but, is still available in high quality and at a high price, the rich not the poor are willing to pay. However, if technological progress is predominantly driven by process innovations, inequality will be detrimental to long run growth. When the majority of households are extremely poor, there is little potential to open markets for mass consumption and consequently the investments in process innovations of low quality and low cost are trivial. In the presence of complementarities between the innovations of process and product, the connection between inequality and growth is hump-shaped. The complementarities imply that an economy that has invested little in the innovation process is likely to benefit more from process innovations and vice versa. In this case, the very high and very low levels of inequality are detrimental to the growth.

The analysis of Foellmi & Zweimüller (2009) has predicted that in the early stages of development (before the introduction of mass production technologies) inequality is beneficial for growth because technical progress is essentially driven by the introduction of new goods for which the rich are willing to pay high prices. In the advanced stages of development (after the introduction of mass production technologies), growth is more significant in more egalitarian societies because process innovations become the essential foundation for growth. To produce the incentive for adopting these technologies, large markets and a high purchasing power of the lower classes are considered necessary.

2. Model and data

Our work estimates Technological Change (this is the explained variable) according to the Initial Inequality, Income, Human Capital and Distortions of the Market (these are the explanatory variables). This model is inspired from the work of Weinhold & Nair-Reichert (2009).

The central model of our work is as follows:

$$\text{Technological Change}_{i,t} = \alpha_i + \beta_1 \text{ Inequality}_{i,t} + \beta_2 \text{ Income}_{i,t} + \beta_3 \text{ Primary Education}_{i,t} + \beta_4 \text{ Secondary Education}_{i,t} + \beta_5 \text{ Higher Education}_{i,t} + \beta_6 \text{ PI}_{i,t} + \mu_{it}$$

Where "i" represents each country and "t" represents each time period (with t=1, 2 ...T). Based on the opinion of Griliches (1995): ''. . . patents appear to be a good indicator . . . for inventive activity...[only] at a very aggregated level.", Technological Change is measured by the number of patents filed by residents and non-residents. Inequality $_{i,t}$; Income $_{i,t}$; Primary Education $_{i,t}$; Secondary Education $_{i,t}$; Higher Education $_{i,t}$ and PI $_{i,t}$ are respectively, Inequality, Income, Primary Education, Secondary Education, Higher Education and the Market Distortions for country i at time t and μ_{it} is the error term.

The data used to estimate our model has been taken from several sources. Inequality is derived from the World Institute for Development Economics Research (WIDER, 2008) (those that are available and refer to the gross income, the entire population, the household and the total geographic coverage). This variable is measured by the Gini coefficient. Income is withdrawn from the data of the Penn World Tables (Heston & Summers, 2009) version 6.3, knowing that it is measured by the log of real GDP per capita. Statistics of Human Capital represented by the average years of Primary, Secondary and Higher Education, come from the database International Data on Educational Attainment: Updates and Implications (Barro & Lee, 2010). Market Distortions are also withdrawn from the data of the Penn World Tables (Heston & Summers, 2009) and they represent the level of the price of investment. Concerning Technological Change, it is taken from the World Intellectual Property Organization (WIPO, 2010). The sources and the detailed definitions of each of these variables are shown in Table 1.

Table 1: Summary of Statistics

Variable	Measure	Source	Mean	Standard Deviation	Minimum	Maximum
Technological Change	Log of the number of patents filed by residents and non-residents	World Intelectual Property Organisation (WIPO, 2010)	2.833	0.739	0.301	5.115
Inequality	Log of GINI coefficient	World Institute for Development Economics Research (WIDER, 2008)	1.62	0.124	1.201	1.889
Income	Log of real GDP per capita	Penn World Tables version 6.3 (Heston & Summers, 2009)	8.411	0.798	6.521	10.475
Primary Education	Average years of primary schooling in population aged over 15.	International Data on Educational Attainment: Updates and Implications (Barro & Lee, 2010).	4.262	1.872	0.175	8.833
Secondary Education	Average years of secondary schooling in population aged over 15.	International Data on Educational Attainment: Updates and Implications (Barro & Lee,	1.89	1.346	0.082	5.706

		2010).				
Higher Education	Average years of higher schooling in population aged over 15.	International Data on Educational Attainment: Updates and Implications (Barro & Lee, 2010).	0.261	0.224	0.007	1.095
IP	Log of price level of investment	Penn World Tables version 6.3 (Heston & Summers, 2009)	1.679	0.179	1.078	2.323

Unlike other works, our model focuses on Technological Change with a sample of 48 developing countries and 453 observations. Our panel is unbalanced, i.e., it does not have the same number of observations in the time dimension for all the countries. Our databases with the means, the standard deviations, the minimum and the maximum ones are shown in Table 1. A list of the countries used in our sample and the years included is given in Table 2.

Table 2: List of the Countries and the Years in Sample

Nation	**Observations**	**Years**
Algeria	2	1988, 1995.
Armenia	7	1996, 1998, 2002-2006.
Bangladesh	10	1977, 1978, 1981, 1983, 1986, 1988, 1989, 1992, 2000, 2005.
Bulgaria	41	1963, 1965, 1967-1990, 1992-2006.
Chile	23	1968, 1971, 1980-1996, 1998-2000, 2003.
China	14	1985-1989, 1991, 1992, 1995, 1996, 1998, 2000-2004.
Colombia	17	1964, 1970-1972, 1974, 1978, 1980, 1988, 1991, 1993-1996, 1998-2000, 2004.
Costa Rica	11	1969, 1974, 1977, 1979, 1981-1983, 1986, 1989, 1990,

		1993.
Croatia	4	1998, 2001, 2003, 2005.
Cyprus	3	2003, 2005, 2006.
Czech Republic	14	1993-2006.
Dominican Republic	7	1976, 1986, 2002-2006.
Ecuador	10	1968, 1988, 1994, 1995, 1999, 2000, 2003-2006.
Egypt	9	1958, 1959, 1965, 1975, 1991, 1995, 1996, 2000, 2004.
El Salvador	4	1977, 1991, 1994, 1995.
Estonia	13	1994-2006.
Ghana	3	1987, 1989, 1992.
Guatemala	6	1987, 1989, 1998, 2000, 2003, 2004.
Honduras	7	1990-1992, 1995, 1996, 1998, 1999.
India	32	1951-1961, 1963-1970, 1973-1975, 1977, 1986-1992, 1999, 2004.
Indonesia	11	1970, 1976, 1978, 1980, 1984, 1987, 1993, 1996, 1999, 2002, 2005.
Iran	7	1969-1972, 1974, 1998, 2005.
Kazakhstan	6	1993, 1996, 2001, 2003, 2005, 2006.
Kenya	9	1976, 1977, 1981-1983, 1999.
Kyrgyz Republic	8	1996-2003.
Malawi	6	1969, 1977, 1983, 1985, 1993, 1997.
Malaysia	7	1989, 1990, 1992, 1995, 1997, 1999, 2004.
Moldova	4	1993, 2000-2002.
Mongolia	3	1995, 1998, 2002.

Morocco	6	1955, 1965, 1970, 1985, 1991, 1995.
Nepal	2	1976, 1977.
Nicaragua	2	1993, 1998.
Pakistan	16	1964, 1966-1969, 1971, 1992, 1979, 1990-1993, 1996, 2002, 2004, 2005.
Panama	6	1980, 1989, 1991, 1995, 1996, 2000.
Peru	13	1972, 1981, 1986, 1991, 1994, 1997, 1999-2005.
Philippines	10	1965, 1971, 1975, 1981, 1985, 1988, 1991, 1997, 2000, 2003.
Romania	18	1989-2006.
Singapore	6	1972, 1977, 1997, 1998-2000.
Sri Lanka	11	1953, 1963, 1970, 1973, 1979, 1980, 1982, 1986, 1987, 2000, 2002.
Tajikistan	3	1999, 2003, 2004.
Thailand	11	1981, 1986, 1988, 1990, 1992, 1994, 1996, 1998-2002.
Trinidad and Tobago	5	1958, 1965, 1971, 1976, 1992.
Tunisia	6	1965, 1975, 1980, 1985, 1990, 2000.
Ukraine	8	1995-1997, 1999-2002, 2005.
Venezuela	21	1976-1987, 1989-1994, 1996, 1997, 2000.
Yemen	2	1998, 2005.
Zambia	7	1970, 1972, 1975, 1976, 1991, 1993, 1996.
Zimbabwe	3	1969, 1990, 1995.

The database of Deininger & Squire (1996) and later that of the World Institute for Development Economics Research, despite considerable improvements, still has several problems. On the one hand, the Gini coefficients are not all based on identical estimation units. For example, some are based on expenses, others on income and others on consumption. Trying to overcome this problem, we have added 6,6 points to the Gini coefficients based on the expenditures and the consumption (Deininger & Squire, 1996). On the other hand, it shows the limited number of the available observations for several countries and for several periods of time. This has pushed us to work with an unbalanced panel.

3. Estimation

The standard methods for estimating the panel are the fixed effects or the random effects. The estimated coefficients are significantly different in the two cases. The specification test of Hausman (1978) may be an evaluation means. For our sample, the realization of the statistic of Hausman test is 5.99. Given that the model has six variables (K = 6), this statistic follows a Chi-square with six degrees of freedom. The threshold is 12.592. We, therefore, accept the null hypothesis of absence of correlation between the individual effects and the explanatory variables. Thus, we have to privilege the adoption of a random effects model and retain the GLS estimator (BLUE estimator). Therefore, there is no commonality between countries and the error term decays.

We will examine the influence of the key variables on Technological Change: the level of Income, the Human Capital, the Inequality and the Investment Price. Not only are most of the estimated coefficients consistent with those traditionally reported in the literature, but also most of them should be significant. Our main research question in this model, wonders whether the exogenous differences in initial conditions of a country can, through their effects on inequality and institutions, explain the innovation.

The coefficient of Income is positive and highly significant. An increase in Income leads to an increase in Technological Change. We have found a negative and highly significant effect for Primary Education and a negative and highly significant effect for Secondary Education as well. Higher Education makes a positive and highly significant influence on Technological Changes. This result shows that the level of education and human capital is very much correlated with the Technological Changes. Thus, Higher Education is the only one which influences Technological Change positively. This shows that an increase of Higher Education and higher qualifications increase the technological innovations.

The coefficient on Market Distortions is negative and insignificant. An increase in the Price of Investment causes a decline in the Technological Changes. And finally, the coefficient on inequality is negative and highly significant. Therefore Inequality plays a crucial role in determining the technology. A negative relationship between Inequality and Technological Change can be confirmed for a sample of developing countries. Thus, Inequality constitutes an obstacle to technological progress. An increase in the Gini coefficient for a country of 1 point is correlated with a decrease in the number of the patents filed or the Technological Change of 2.269. As we pointed out in the literature review, the existing theoretical models yield very different predictions regarding the impact of a greater inequality level on technological change depending on whether one considers process or product innovation; even within product innovation, the predictions are different whether one considers the introduction of a new good, a new variety, or a new quality of an existing good. One could then argue that the negative and significant impact captured by our model constitutes the overall effect of varying inequality degrees, once all the different forces have been taken into account. The overall results of our estimation are reported in Table 3.

Table 3: Result of the Estimation

Estimation	**Fixed effects**	**Random effects**
Constant	3.602 (0.000)	4.5790 (0.000)
Inequality	-2.2013 (0.000)	-2.2692 (0.000)
Income	0.3557 (0.000)	0.2836 (0.000)
Primary Education	-0.0685 (0.018)	-0.0772 (0.004)
Secondary Education	-0.1278 (0.001)	-0.1062 (0.003)
Higher Education	0.2726 (0.204)	0.4623 (0.028)
PI	-0.1630 (0.448)	-0.0233 (0.000)
Countries	48 countries	48 countries

Note: The values in parentheses represent probabilities.

For Weinhold & 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. Weinhold & Nair-Reichert have found that the share of the middle class, explains the models of residents' patent, while the non-residents patenting is driven more by exogenous factors and global integration. In other words, they have separated the patents filed by residents and the patents filed by non-residents.

Thus, the approach that Weinhold & Nair-Reichert (2009) have adopted to examine how changes in the level of inequality and intellectual property rights may explain the variations in the levels of patenting of residents and non-residents of a country. 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.

Weinhold & Nair-Reichert (2009) have also found a positive effect of income represented by the log of real GDP per capita and human capital represented by the average years of study for adults (25 years and over) on innovation. The work of Beilock & Dimitrow (2003) has similarly shown that the GDP per capita has stimulated technological change. Aissa & Teffahi (2007) have found that the rate of technological diffusion slows when inequality exceeds a threshold. Beyond the threshold of saturation, inequality ceases to be a factor stimulating the proliferation of technologies and becomes a part of the diffusion decelerator. Conciaçao, Faria, Padilla & Preto (2005) have found a positive relationship between technology and inequality. They have also found that the effect of human capital and the growth of GDP per capita on technology diffusion are positive and significant regardless of the indicator measuring human capital. For them, an increase in the purchasing power causes an increase in the use of technology.

For Foellmi & Zweimüller (2009) 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. The 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 (Foellmi & Zweimüller, 2009; Mani, 2001; Zweimüller, 2000).

Bertola et al. (2005) 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.

In addition, our work challenges the current belief that Income Inequality has a positive relationship with Technological Changes. Our results suggest that an increase in a country's level of income inequality has a significant negative relationship with the subsequent Technological Changes. It is important to try to find the reasons behind the differences between our results and the previous results. First, Weinhold & Nair-Reichert have been interested in the relationship between inequality and innovation in the medium-term period from 1994 to 2000; while, our work focuses on the relationship in the long term. Then, Weinhold & Nair-Reichert have based their research on a sample of heterogeneous countries composed of developed countries and developing countries, where there is a problem of homogeneity; while, we focus on developing countries. Finally, Weinhold & Nair-Reichert have measured inequality variable differently using the domestic size of the middle class; whereas, our work uses the Gini index. Also, our other explanatory variables differ from those of Weinhold & Nair-Reichert. Therefore, modifying one or more of these factors should explain why this paper finds the opposite relationship between inequality and Technological Changes than previously reported.

We can therefore say that the effect of inequality on technological change may differ depending on the country's characteristics. The same result has been found by barro (2008) for a relationship between inequality and economic growth. However, he has found that inequality is harmful for growth in developing countries and good for growth in developed countries. He has explained this by the greater effect of credit market constraints in poor countries. Also, our work differs from those of Zweimüller (2000), Mani (2001), Foellmi & Zweimüller (2006, 2009), Bertola et al. (2005) and Latzer (2013) because we are interested in the overall effect of inequality on technological change.

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

4. Conclusion

We are interested in the theoretical and empirical aspects of the connection beginning from the inequalities towards the technological changes. For this reason, we have presented a background for some works concerned with the neo-Schumpeterian approach. Then, we have moved to our empirical validation based on our specified model. Before interpreting the obtained results, we have presented: the sample of countries under study (a homogeneous sample composed of developing countries), the variables in question, the sources of data and the specified model. We have found a negative effect of inequality on technological changes for 48 developing countries. Finally, we have tried to list the points of convergence and divergence between our results and the results found in previous studies.

References

Acemoglu, D. (2002). Technical Change, Inequality, and the Labor Market. *Journal of Economic Literature*, 40(1), 7-72.

Aghion, P. (2002). Les défis d'une nouvelle théorie de la croissance. *L'actualité économique*, 78(4), 459-486.

Aissa, A. A., & Teffahi, B. (2009). *L'inégalité et la diffusion des TIC*. Paper presented at the international meeting : Les objectifs du Millénaire pour le développement (OMD) Progrès et Perspectives : le cas des pays maghrébins, Tunisia, juin.

Arellano, M., & Bond, S. R. (1991). Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations. *Review of Economic Studies*, 58(2), 277-297.

Barro R. J. (2008). Inequality and Growth Revisited. Working paper, *Regional Economic Integration* (11).

Barro, R. J., & Lee, L. W. (2010). International Data on Educational Attainment: Updates and Implications. Available at: http://www.barrolee.com/data/dataexp.htm.

Beilock, R., & Dimitrova, D. V. (2003). An Exploratory Model of Inter-Country Internet Diffusion. *Telecommunications Policy*, 27(3), 237-252.

Bertola, G., Foellmi, R., & Zweimüller, J. (2005). *Income distribution in macroeconomic models*. Princeton: Princeton University Press.

Conciaçao, P., Faria, P., Padilla, B., & Preto, P. T. (2005). Does Inequality Hinder the Diffusion of Technology ? Preliminary explorations. Working paper.

Deininger, K., & Squire, L. (1996). A New Data Set Measuring Income Inequality. *The World Bank Economic Review*, 10(3), 565-591.

Ehrhart, C. (2009). The Effects of Inequality on Growth: A Survey of the Theoretical and Empirical Literature. Working paper series, Society for the study of economic inequality, ECINEQ.

Falkinger, J. (1994). An Engelian Model of Growth and Innovation with Hierarchic Demand and Unequal Incomes. *Ricerche Economiche*, 48, 123-139.

Falkinger, J., & Zweimüller, J. (1996). The Cross-country Engel-curve for Product Diversification. *Structural Change and Economic Dynamics*, 7(1), 79-97.

Foellmi, R., & Zweimüller, J. (2006). Income Distribution and Demand-Induced Innovations. Working paper, Institute for Empirical Research in Economics, ISSN 1424-0459.

Foellmi, R., & Zweimüller, J. (2009). The Macroeconomics of Model T. Working paper.

Galbraith, J. K. (1998). *Created Unequal*. New York and London: Free Press.

Griliches, Z. (1995). R&D and productivity: Econometric results and measurement issues. in P. Stoneman (Eds.), *Handbook of the economics of innovation and technological change*(pp. 52-89). Oxford, UK and Cambridge, US: Blackwell.

Grossman, G., & Helpman, E. (1992). *Innovation and Growth in the Global Economy* (2nd edition). Cambridge, Mass., et London England: MIT Press.

Heston, A., & Summers, R. (2009). The Penn World Tables (Mark 6.3). Center for International Comparisons of Production, Income and Prices, CIC.

Huw, L. (1999). Endogenous Technological Change and Wage Inequality. *American Economic Review*, 89(1), 47-77.

Jaramillo, F. (1995). *Distribution du revenu, composition de la demande et croissance.* MAD, Université de Paris I: mimeo.

Latzer, H. (2013). *Beyond the Arrow effect: income distribution and multi-quality firms in a Schumpeterian framework*. Working paper, Catholic University of Louvain (IRES).

Li, C. W. (2003). *Income Inequality, Product Market, and Schumpeterian Growth*. University of Glasgow: Mimeo.

Mani A. (2001). Income Distribution and the Demand Constraint. *Journal of Economic Growth*, 6(2), 107-133.

Mendez, R. (2002). Creative destruction and the rise of inequality. *Journal of Economic Growth*, 7(3), 259-281.

Murphy, K., Schleifer, A., & Vishny, R. (1989). Income Distribution, Market Size and Industrialization. *Quarterly Journal of Economics*, 104(3), 537-564.

Nurkse, R. (1968). *Les problèmes de la formation du capital dans les pays sous développés (suivi de) Structure du commerce international et développement économique*. Paris: Cujas.

Schmookler, J. (1966). *Invention and Economic Growth.* Cambridge, Mass: Harvard University Press.

Segerstrom, P., Anant, C. A. T., & Dinopoulos, E. (1990). A Schumpeterian Model of Product Life Cycle. *American Economic Review*, 80, 1077-1091.

World Bank (2010). 2010 World Development Indicators. Data Report, World Bank, Washington, CD ROM.

Weinhold, D. & Nair-Reichert, U. (2009). Innovation, Inequalities and Intellectual Property Rights. *World Development*, 37(5), 889-901.

World Intellectual Property Organization (WIPO). (2010). Available at: http://www.wipo.int/portal/en/index.html

World Institute for Development Economics Research (WIDER). (2008). World Income Inequality Database (WIID, 2008). Available at: http://www.nsd.uib.no/macrodataguide/set.html?id=49&sub=1.

Zweimüller, J. (2000a). Schumpeterian Entrepreneurs Meet Engel's Law: The Impact of Inequality on Innovation-Driven Growth. *Journal of Economic Growth*, 5(2), 185-206.

Zweimüller, J. (2000b). Inequality, Redistribution, and Economic Growth. *Empirica*, 27, 1-20, Paper presented at the Meeting of the Austrian Economic Association 1999.

Zweimüller, J., & Brunner, J. (2005). Innovation and Growth with Rich and Poor Consumers. *Metroeconomica,* 56(2), 233-262.