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IS INEQUALITY GOOD FOR GROWTH?

AN EMPIRICAL ASSESSMENT

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A mia madre,

specchio di vita, pioggia scrosciante e sole accecante,

sempre presente, sempre senza mezze misure.

A mio padre,

mio faro di ambizione

in quelle notti che sanno di incertezza e paura.

A mio fratello e mia sorella,

il regalo più bello che la vita mi ha donato.

A mia nonna,

alla sua costante attesa del mio rientro,

alle sue carezze, ai suoi baci.

Abstract

This paper reconciles the controversial findings about the relationship between income inequality and economic growth by proposing different approaches for the analysis of the problem.

In Chapter 1 the two variables are presented, with the explanation of definitions and measurements. Then theoretical analysis is presented, with the light put on the reverse causality relationship that exists between them.

Chapter 2 focuses on the specific effect that technological progress has on income inequality. Specifically, income inequality tends to rise with the technological progress. Redistributive policies are implemented to limit this effect, even if they do have some costs, especially due to distortions in agents' effort or saving decisions.

In Chapter 3 the econometric model is introduced. The first regression estimates the effect GDP growth has on inequality. Furthermore,the ICT investment variable, as an instrument to measure the technological progress, is introduced. Once we gather the two variables together in *reg 3* the two coefficients don't result significant.

The countries are divided in macro groups; interactions variables between these groups and both the GDP growth and ICT investment are created. Both the GDP growth and the ICT investment coefficient are now significant, and they both have a positive sign.

Analysing the interaction coefficients, the countries differences in the GDP growth and technological progress increase effect on inequality emerge.

In conclusion, the empirical evidence shows which countries adopt the most efficient redistributive schemes, controlling the best the rise in inequality.

Table of Contents

Abstract 3

1 Growth and Inequality: Definitions of the Variables 5

1.1 Endogenous Causality of Growth and Inequality 12

1.1.1 How Inequality affects Growth 12

1.1.2 How Growth affects Inequality 18

2 Technological Progress and Income Inequality 23

2.1 Redistributive Policies to counteract Inequality 28

3 Empirical Evidence: The Econometric Study 33

3.1 The Econometric Model and the Purpose of the Study 33

3.2 Data Description 34

3.3 Estimation of the Results 37

4 Conclusions 41

Bibliography 42

1

Growth and Inequality: Definitions of the Variables

The rising of inequality is a widespread concern for the serious implication it has for parity, growth and macroeconomic stability. It leads to a suboptimal use of human resources, it causes investment-reducing political and economic instability, concentrating the political and decision making power in the hands of a few. Sustained high level of inequality has also social costs, diminishing people incentive effort and increasing phenomenons of nepotism, corruption and misallocation of resources. Citizens lose also the confidence in institutions, eroding social cohesion and confidence in the future. How can we define inequality?

We can make a distinction between inequality of outcomes, measured by income, wealth or expenditure, and inequality of opportunities, due to the different circumstances beyond the individual control, as gender, ethnicity, location of birth or family background.

Consumption possibilities of households are determined by their income after taxes and transfers and empirical evidence shows there is a gap between groups of individuals receiving most of the income and other joining only a little part. This concept can be defined as Income Inequality. According to the report by the Stiglitz-Sen-Fitoussi Commission (2009), the most comprehensive income definition is the Household Adjusted Disposable Income, this measurement takes into consideration publicly provided in-kind transfers, as public spending on education and health care. The process of "refinement" of this income can be summarised by $figure1.1$, where we arrive from the starting individual labour earnings to the adjusted household disposable income. There are two categories of income inequality measures, a one-number summary statistics, like the most-quoted Gini index, and the information about the income distribution at various points, such as the percentile ratios.

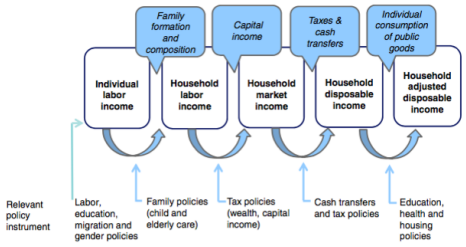

Figure 1.1: From individual labour earnings to adjusted household disposable income
Sources: OECD Economics Department Policy Notes, No.9.January 2012.

While the first index analyses the whole income distribution, the latter provides a picture of inequality at specific distribution points. Defining the Lorentz curve as the cumulative share of income accruing to various quintiles of households, the Gini coefficient is calculated as the ratio of the area between perfect-equality Lorentz curve and the actual Lorentz curve over the area under perfect-equality Lorentz curve. The perfect equality one is a 45 straight line, so the further is the actual one, the highest is the inequality. This definition implies the coefficient would be 0 in case of perfect equality and 1 when the distribution exhibits perfect inequality.

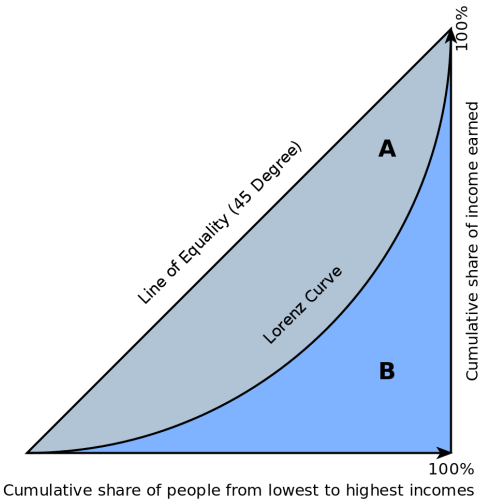

Figure 1.2: Calculating the Gini Coefficient
Sources: Asociologist.com

These inequality measures are constructed using standardised household surveys, which w exhibit some limitations:

i) The richest often fail to respond or tend to under-report their income;

ii) Non-response rate and misreporting vary across countries;

iii) Income data don't account for components as home production and imputed rent;

iv) Some taxes or social securities are not included, like for the social security contributions paid by employers or indirect and corporate income taxes.

The dispersion of household labour income accounts for the 75% of the average OECD dispersion, while the 25% is caused by the self employment and capital income combined. This unequal distribution of labour income is driven by divergences in full-time job wages, share of part-time occupations, non-employment rate and household formation. $Figure$ 1.3 illustrates how labour income inequality varies across countries, taking also in consideration specific national characteristics.

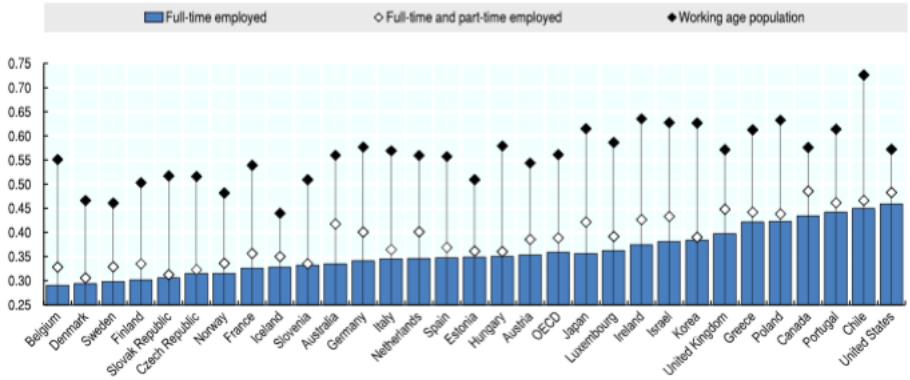

Figure 1.3: Gini Index, 2008
Note:The group of employed individuals includes both dependent and self-employed individuals. The working age population includes all persons aged 15 to 64 except for students and people above the country's statutory retirement age. The Gini coefficients take into account labor earnings only; the precise data for labor earnings differs across countries. 2007 for France, Korea and the United States, 2009 for Australia and Japan. The values for the OECD are calculated as unweighted averages across all OECD countries for which data are available.
Sources: Panel Study of Income Dynamics (PSID) for the United States; Household Income and Labour Dynamics in Australia Survey (HILDA) for Australia; National Socioeconomic Characterization Survey (CASEN) for Chile; Korean Labour and Income Panel Study (KLIPS) for Korea; Luxembourg Income Study (LIS) for Israel; Japan Household Panel Survey (JHPS) for Japan; Swiss Household Panel (SHP) for Switzerland; and European Union Statistics on Income and Living Conditions (EU-SILC) for the other countries.

The OECD Gini index is lowered of about 25% once we deduct taxes and transfers, obtaining

the so called net Gini index, in the late 2000s; the overall redistributive impact is mostly due to cash transfers, as pensions, unemployment and child benefits, while taxes account for only a quarter.

The graph below illustrates the change in the net Gini,1990-2012. It increased substantially in most of the developed countries, while for the emerging markets and developing countries (EMDCs) there was a rise in Asia and Eastern Europe, and a decline in Latin America.

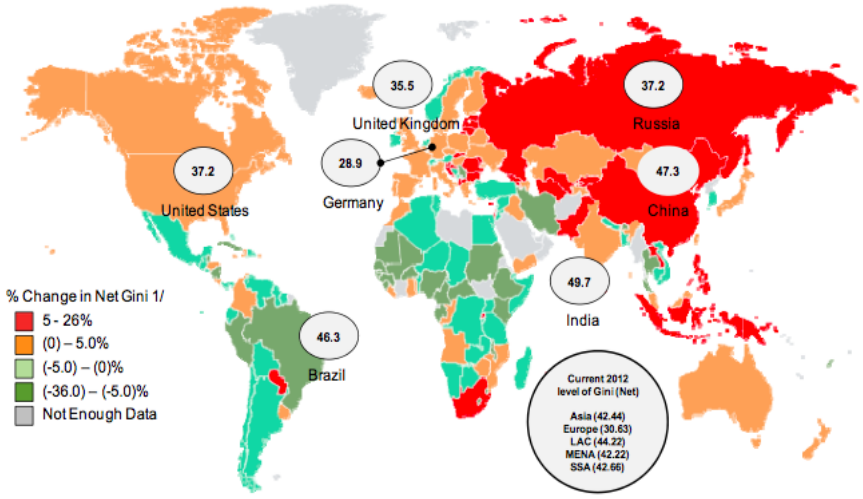

Figure 1.4: Change in Net Gini, 1990-2012.
Note: LAC =Latin America and the Caribbean; MENA = Middle East and North Africa; and SSA = Sub-Saharan Africa. 1/ Change in net Gini from 1990 to 2012 is expressed as a percentage. For missing values, data for the most recent year were used.
Sources: Solt Database; and IMF staff calculations.

Empirical evidence shows inequality is positively related to the redistributive taxation ($figure$ 1.5) and that high tax countries tend to have less progressive households taxes ($figure$ 1.6).

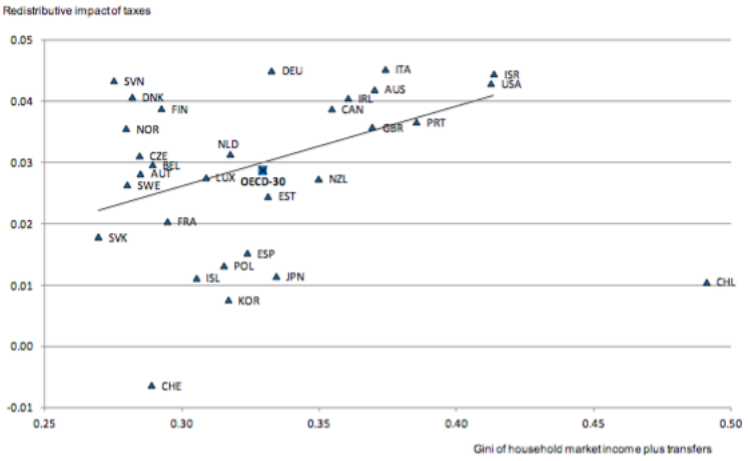

Figure 1.5: Unequal countries tend to redistribute more through household taxes.
Sources: OECD Income Distribution and Poverty Database

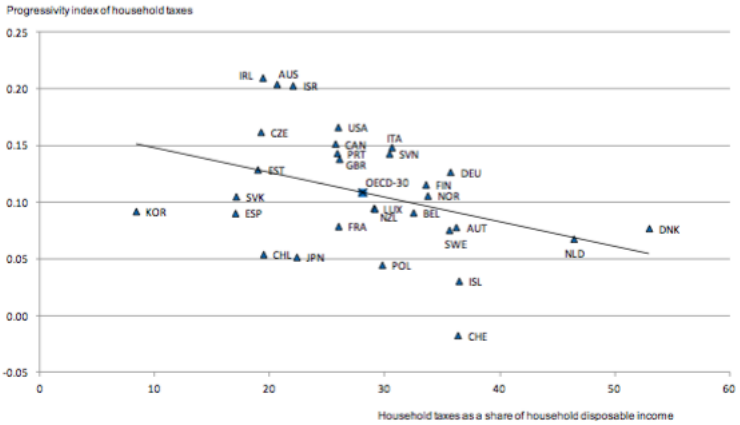

Figure 1.6: High tax countries tend to have less progressive household taxes.
Sources: OECD Income Distribution and Poverty Database

The inequality of outcomes can be estimated in different ways. According to the wealth analysis and the empirical evidence almost half of the world's wealth is now owned by just 1% of the population. Inequality is even more extreme in wealth than income: advanced economies face a rising of concentration of wealth at the top, while EMDCs exhibit strong polarization between urban and local area, as in China, or among social classes, as in India. *Figure* 1.7 clearly highlights the differences between income and wealth inequality in

advanced and emerging markets.

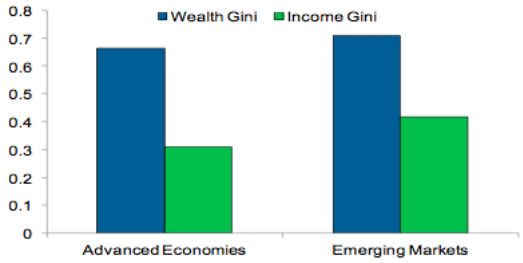

Figure 1.7: Wealth Gini and Income Gini.
Note: Emerging markets include China, India, Pakistan, Thailand, Turkey, Argentina, Mexico, Indonesia, and Brazil.
Sources: Davies and others (2008); Luxembourg Income Study Database; Organisation for Economic Co-operation and Development; Socio-Economic Database for Latin America and the Caribbean; World Bank; and IMF staff calculations.

Health service and access to education are measures for the inequality of opportunities, together with the financial services. Looking to these different elements, the results don't change.

The division between the Rich and the Poor is quite pronounced in some countries and varies a lot; according to $figure$ 1.8, may be as follows:

(i) The Nordic countries plus Switzerland with a below OECD average inequality, little wage dispersion, high employment rate.
(ii) Eight continental European countries (Belgium, the Czech Republic, Estonia, Finland, France, Italy, the Slovak Republic and Slovenia), with a labour market inequality just below the OECD average, little wage dispersion but low employment rate.
(iii) Seven continental European countries (Austria, Germany, Greece, Hungary, Luxembourg, Poland and Spain), Japan and Korea with a labour market inequality above the OECD average and different underlying causes.

(iv) Five English-speaking countries (Australia, Canada, Ireland, New Zeland and the United Kingdom) and the Netherlands with a large share of part-time jobs but employment rate above the average. All countries but for Netherlands have above the OECD average income inequality.

(v) Chile, Israel, Mexico, Portugal, Turkey and US have well above average income inequality, especially originated from the labour market.

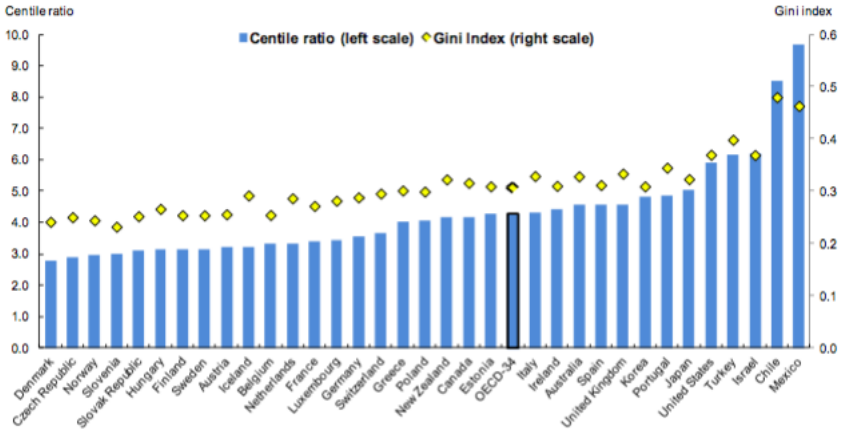

Figure 1.8: Household disposable income: Gap between the 10th and the 90th centileand the Gini index in the late 2000s.
Note: The Gini index ranges from zero (perfect equality) to one (one individual or household receives all the income and the others receive none). Data for France and Ireland refer to the mid-2000s instead of the late 2000s.
Sources: OECD Income Distribution and Poverty Database, OECD Social Expenditure Statistics (database).

Endogenous Causality of Growth and Inequality

Is inequality which stimulates the growth or is the economic growth of a country which affects its income inequality?
Several studies analyses both the two issues and a common result is the uncertainty regarding a sure conclusion.
What follows is an introduction of these different casual relationships.

How Inequality affects Growth

The trade-off between reducing income inequality and boosting economic growth was introduced was during the 1950' and 1960' by the economists Nicholas Kaldor and Simon Kuznets. During the more recent years this kind of studies were continued with a series of cross-country growth regressions, having the inequality as the independent variable, and a negative and just significant coefficient. Furthermore, this negative relationship seems to depend on exogenous factors like the aggregate wealth, political institutions, and the level of development.
More recent papers have developed a positive relationship between inequality and growth but less attention was dedicated on them as empirical evidence contradicts this positive coefficient.
Deininger and Squire (1996) started from this incongruence of results and questioned the robustness of the validity of this negative association between inequality and growth and the potential of econometric problems affecting the results, such as omitted-variable bias and measurement error in inequality. For example, evidence demonstrates that more unequal countries tend to undereport their inequalities statistics and, given that they also grow more slowly than more equal countries, this could generate a negative bias in the cross-country analysis of the effect of inequality on growth. Another problem may be the correlation of omitted variables like a country's degree of capitalism, support for entrepreneurship and the labour-market flexibility which may positively bias the coefficient of inequality. Vice versa the omitted level of corruption may negatively bias it.
The cross-country work doesn't answer to the question of the effect of a change in a specific country level of inequality in its growth, but just shows the long-term patterns that countries with lower level of inequality tend to grow more quickly. For the more specific question we need the use of a panel data estimation.
Countries have different definition of key variables and difference accuracy data collection, with a relevant scarcity for the poorest ones. A complete and correct income distribution

measurement is difficult to be found and unreliable data are very common. So, although most of the researches are aware of the low quality of their data, they sustain that, since there is no good instrument for inequality, it's very difficult to correct for this problem.
Deininger and Squire started to collect more consistent data on inequality, having a three points minimum standard of quality:

- data must be based on household surveys
- the population covered must represent the entire country
- the measure of income must be comprehensive, including the self-employment one, non wage earnings and non monetary income

Applying the cross-country analysis with this new data set, the coefficient on inequality was still negative, becoming highly significant with the inclusion of the regional dummy variables, meaning that the region-specific factors are not captured by the explanatory variables.
The correlation of the time-invariant unobservable country characteristics with the variables can be eliminated through the use of the panel estimation, which requires data both across time for each country and across countries. This big request made them impossible until Deininger and Squire completed their new data set.
Their panel data analysis showed a highly robust and significant positive relationship between the increase of country's inequality and economic growth in a short and medium term, as there were no enough data to make estimations over periods longer than 10 years. This should suggest that the country-specific and time-invariant variables, previously omitted, negatively bias the coefficient of inequality. This doesn't mean there is an inconsistency with the cross-country analysis mentioned before and the panel data, as the first only focused on a long-term relationship with the two variables only across countries and it may be that, over a longer period, the positive coefficient could diminish or even reverse, as it happens in the latter.
These findings have disappointing implications, like that countries have to face a trade-off between reducing inequality and improving growth performance.

This trade-off wasn't perceived by Hongyi Li and Heng-fu Zou (1998). They analysed the question under a different approach, showing how inequality can be good for growth. According to them we can divide the government spending, that appear in the GDP accounting into production services, which enter the production function, and consumption services, which enter the utility function. With the typical consumption taxation, more equal distribution, with a consistent middle class, creates higher income taxation and so a lower economic

growth, through the following mechanism:

i) Inequality decrease
ii) Taxation increases
iii) Government spending decreases
iv) GDP decreases
v) GDP Growth decreases

Aghion, Caroli and Garcia-Penalosa (1999) strongly disagrees with this conclusion. They proposed a new growth theory and their starting point is the technical difference between wealth inequality and wage inequality. The first one deals with the distribution and how it affects both the aggregate output and the individual investments in human or physical capital. The latter is linked with the possible changes in the sources of income, like labour earnings, so we use the first to avoid the influence of redistributive policies or interest rate.
Their theoretical analysis shows that with imperfect markets and diminishing returns to capital wealth inequality is bad for growth, so there' s a negative relationship between the two. Growth could be enhanced with a redistributive pattern from rich to poor people, to create investment opportunities for physical and human capital. This human capital investment results to be highly expensive, especially in underdeveloped countries, and it exhibits a decreasing return. The result is that family wealth becomes the major determinant of such investment and the evidence of inequality effect on agents' investments in education predict a negative relationship. Another proof that wealth inequality is negative for growth is the fact that borrowers tend to under invest in case of an unobservable effort and limited liability. Also in this case redistribution with a lump-sum tax or transfer may be growth enhancing. The negative effects of an ex post distortionary taxation may be (a) reduction of lenders' incentive to invest, after a decrease in their return, and (b) the moral hazard that decrease the effort of borrowers in presence of limited liability.
Then the final result of taxation depends on whether the effect of taxation on the wealthiest individuals is smaller or greater than the positive effect on the agents with the smallest wealth.
In the cases just analysed the initial wealth distribution causes the inequality and the suggested solution is by using taxes and subsidies. This is not anymore the case if the inequality is created by the social and institutional environment that influences the access to the investment projects. In this case there is the need of structural policies to restructure the core financial institution.

Philip Keefer and Stephen Knack (2000) analysed the impact of inequality, seen as one type of polarization, their main topic of the paper, on growth. They mentioned four different channels of influence, the already nominated reduction of the access to credit market and the decrease in government expenditure after an income tax to favour the redistribution. The new entries in our discussion are the size of the market and the political violence.

Middle class is the key point of the issue according to Murphy, Shleifer and Visnhy (1989). They linked a successful industrialization with a large market composed of a big slice of middle and upper class consumers, which permits to maximize the increasing return to scale of manufacturers. In case of trade barriers or high fixed costs to export there is the need of a sizeable middle class in the local market to achieve a good level of industrialization. This implies a negative effect of inequality on growth in smaller markets, since in the large ones the size of the middle and upper classes is large, even in case of high income inequality. Data suggest a declining slice of middle class together with a rise of the top 20% one, in both advanced and emerging markets, as we can see from $figure$ 1.9. Political violence together

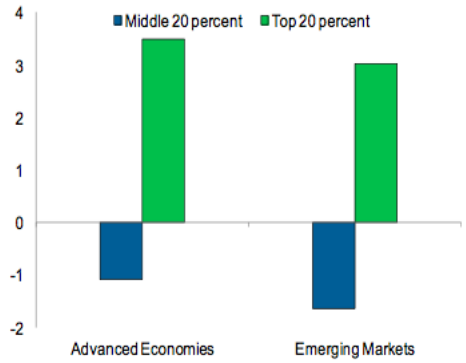

Figure 1.9: Wealth Gini and Income Gini.
Note: Emerging markets include China, India, Russia, Argentina, Brazil and South Africa.
Sources:WDI database and IMF staff calculations.

with inequality retard growth according to the evidence and a statistical analysis predicts that polarization, so for example under the form of inequality, worsen political violence. So, as a

consequence, also growth is worsened.

Is inequality a necessary starting point to make people choose risky entrepreneurship, innovation, seeking large financial rewards? Okun and Bernanke together with Summers gave two different answers to this heterogeneous question.

Okun (1975) theorizes a trade-off between perfect equality and perfect efficiency, so to reach an efficient economy we have to sacrifice a part of our equality goal.

Some drawbacks still exist as this inequality decreases growth if the low income people suffer of poor health and low productivity, causing the country to spend money for their "recovery", both physical and productive; the same can be said if they struggle to invest in education.

Bernanke and Summers (2015) showed that inequality boosts the Saving Glut, so the excess supply of savings with respect to investment, since the rich are less likely to spend one additional $ than the poor. The interest rate falls after this increase in savings supply, boosting asset prices and borrowing; the consequence is an increasing difficulty for the central banks to manage the economy.

The OECD used a large amount of data to construct indexes of magnitude to estimate for a large number of countries and for a long period of time the effect of inequality on growth (2010). The starting point is the theoretical literature, according to which greater inequality might have different and opposite sign effect on growth.

According to the literature already discussed, inequality reduces growth if:

i) High level of inequality makes people no longer trust markets and businesses, so there are low incentives to invest and in extreme cases political instability and social unrest (Alesina and Rodrick 1994; Persson and Tabellini 1994; Bénabou, 1996; Perotti 1996; Alesina and Perotti, 1996; Knack and Keefer, 2000).

ii) Lower-income households are forced to sacrifice a full time education because of the fees it requests. This implies an under-investment and a lower aggregate output than in case of perfect financial market conditions. This view is formalized by Galor and Zeira (1993) in their "human capital accumulation theory".

According to a simple cross-country correlation analysis the Gini coefficient and the education, both secondary and tertiary, are negatively related as we can see in the graph below.

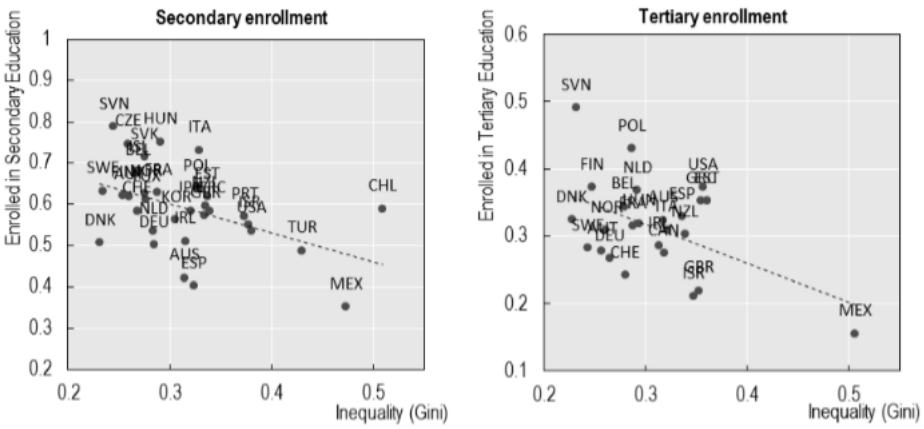

Figure 1.10: Enrollment in Secondary and Tertiary Education.

Note: The graph is obtained combining OECD data on the number of students enrolled (by age class and level of education) with data on population by age class. The ratio of Upper secondary enrolled is computed relative to the population aged 15-19 (20-24 for the ratio of tertiary enrolled). The two ratios are computed in 2010. Inequality (captured by the Gini coefficient) is measured when individuals were aged 10-14, that is in 2005 (left panel) and 2000 (right panel). Both regression coefficients are statistically significant at the 1% level of confidence.

Sources: OECD Income Distribution and Poverty Database.

iii) If the adoption of advanced technologies depends on a minimum amount of domestic demand, which could create a no-ending process, leaving the poorest realties left alone without the possibility of any development challenge (Krueger, 2012, Bernstein, 2013).

Viceversa the inequality increases growth if:

iv) It creates the necessary incentives to work hard, invest and accept risks, to join high rates of return (Mirrlees, 1971; Lazear and Rosen, 1981)

v) It fosters aggregate savings, so capital accumulation, as rich people have a lower propensity to consume (Kaldor, 1956; Bourguignon, 1981).

The final result of the OECD study shows that inequality negatively affects growth especially lowering the investment opportunities of the poorest segments of the population. This may reflect in different education opportunities, affecting non only the level, but also the quality of education.

In a similar way, Gaylor and Zeira (1993) proposed a model predicting heterogeneity in the effects of inequality on aggregate output across different initial income levels countries.

Specifically, the within-country rise in income inequality increase the Investment-GDP ratio in poor countries but decrease it in high and middle income countries. Same happens for human capital, which increase in poor countries and decrease in rich ones after an increase in income inequality. So countries with different initial wealth distributions follow different growth paths and converge to different steady states. This initial distribution affects in the short run the investment level in human capital, but these decisions made in turn determines the long-run distribution of income and finally of wealth over time. Their paper shows how different dynasties, in which we can divide the population, exhibit some specific economics dynamics depending on initial wealth. Rich dynasties invest in human capital, work as skilled and leave a large amount of capital. Poor dynasties inherit less, work as unskilled and consequently leave less to their children. The initial distribution of wealth determines the dimension of these dynasties and the final long-run equilibrium of the economy. To achieve a good economic growth there is the need of a large middle class.

How Growth affects Inequality

Does growth increase income inequality or does is contribute to reduce the pronounced differences inside the population contest?

Using both cross-country data and time series, Simon Kuznets (1963) found an inverted U relation between income inequality and GNP per head. This result described the evolution of the income distribution, starting from a rural society till an industrialized one. As shown in Figure 11, inequality increases during the initial phase, because of urbanization and industrialization, and decreasing later on, once industries would have touched also the rural labour force. This curve is presented in $figure$ 1.11.

Other researches have focussed on three aspects, trade, technological change and organizational change. Technological change is the most important factor as the effect of the other two on inequality is associated with technical change.

Technological change is considered both the major source of economic growth and the vector through which this growth influences the distribution of earnings. The evidence demonstrates that, because of it, there's even a bigger fracture between the job opportunities of skilled and unskilled workers, fracture that can be seen as a result of an existing wealth inequality.

The question is why this strong device should help only skilled people, without creating a more equal redistribution of income. Let's go inside the problem.

The Value of the Marginal Product, VMP, is the monetary value associated to a change in the total product after the addition of one more unit of labour. Mathematically is the price times

the marginal product, derived from the specific production function.

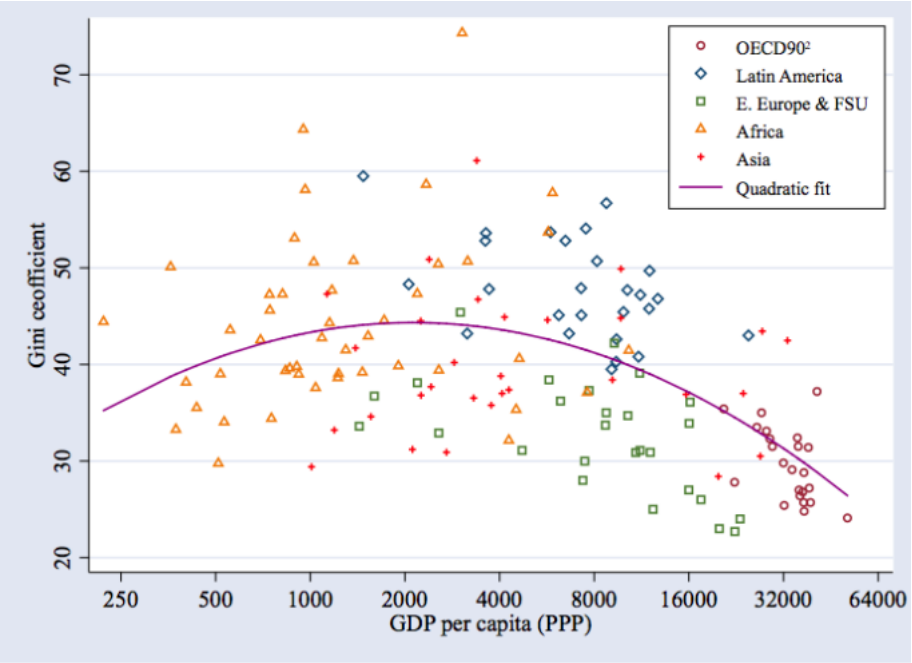

Figure 1.11: Kuznets Curve

Note: Inequality in a cross section of countries with a quadratic fit.

Sources: Asociologist.com

Let's suppose some basic Cobb-Douglas production functions for skilled (s) and unskilled (u) workers:

$$Y_u = A_u E_u^{\alpha} \tag{1.1}$$

$$Y_s = A_s E_s^{\alpha} \tag{1.2}$$

The short run employment decision is achieved equating the VMP to the value of the wage.

The idea is that the marginal gain from hiring an additional worker equals the cost of that hire. So our respective VMP are:

$$VPM_u = \alpha P_u A_u E_u^{\alpha-1} \tag{1.3}$$

$$VPM_s = \alpha P_s A_s E_s^{\alpha-1} \tag{1.4}$$

Technology changed the value of A(the efficiency of E), improving the value of the skilled workers. High technological products can be seen as complements. International trade forced the products of the unskilled to compete in price with foreigners, so P_u decreased, while P_s increased as the marginal cost increase and the demand decreases.
The resulting situation is:

$$VPM_u = \alpha(\downarrow P_u) A_u (E \downarrow)_u^{\alpha-1} \tag{1.5}$$

$$VPM_s = \alpha(\uparrow P_s) A_s (E \uparrow)_s^{\alpha-1} \tag{1.6}$$

The final result is an increase in the demand for labour of the skilled ($figure$ 1.12) and a decrease for the unskilled workers ($figure$ 1.13). We define $w(E)$ the amount of wage as a function of the unit of labour used. In the labour market graph, we draw the Demand and Supply as the function $w(E)$. $w*$ is the equilibrium wage. As we can see from the graph it is higher for the skilled and lower for the unskilled. The final effect is an higher average wage.

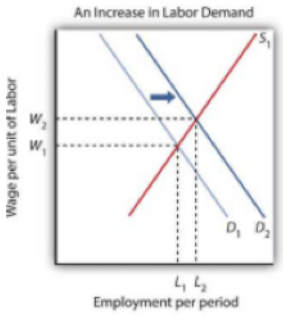

Figure 1.12: Labour Demand Increases.

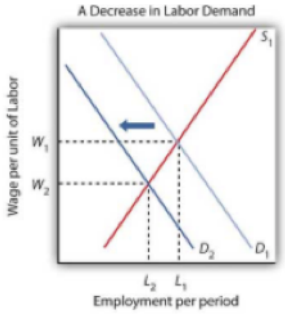

Figure 1.13: Labour Demand Decreases.

The effect of the influence of the growth on earnings inequality also depends on the specific country institutional characteristics, in particular on labour market institution. For example “deunionization”, together with a decrease in the minimal wage, contributed to the rise in wage inequality just analysed in both US and UK. So the specific aspects of the labour market institution may both magnify or dampen the impact of the technological change upon wage inequality.

Thomas Piketty, in is seminal work “Capital” (2013), gave us a “modern” interpretation of the central themes discussed by Marx, taking advantage of two centuries worth of hard data. He defined inequality as one of the most controversial attributes of the capitalism and according to him there’s no reason to think capitalism will naturally reverse it.
According to his analysis, the strongest redistribution of income, happened after the wars and the great depression, caused by a physical destruction of capital, nationalization, taxation, inflation and bankruptcies. A factor that limits the inequality is the rapid growth, both from large productivity gains or growing population. Instead a slow and constant growth seems to positively influence the inequality. His final suggestion for the governments is to adopt a

global tax on wealth, to prevent an increase in inequality and the consequent political and economic instability.

2

Technological Progress and Income Inequality

Up to now we saw how income inequality can affect growth, and vice versa how the economic growth can alter the existing income inequality. Focussing on the latter, I would proceed analysing the concepts of inequality and technological progress, the engine of the economy, a quite efficient instrument to foresee the specific growth of a country.

Recent trends are largely characterized by an increasing level of inequality, with a simultaneously rise in unemployment. The first ascribed element is technology, and the greater importance given to cognitive skills in the wage function. These trends can be seen in the graphs below.

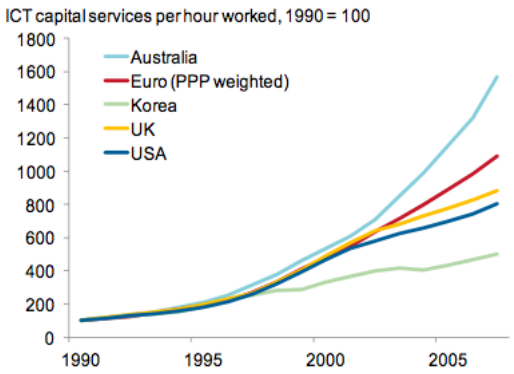

Figure 2.1: Use of Information and Communication Technology (ICT).
Note: Skill premium measures the relative earnings from employment after completing tertiary education compared to the earnings after completing upper- and post-secondary non-tertiary education.
Sources: Organisation of Economic Co-operation and Development.

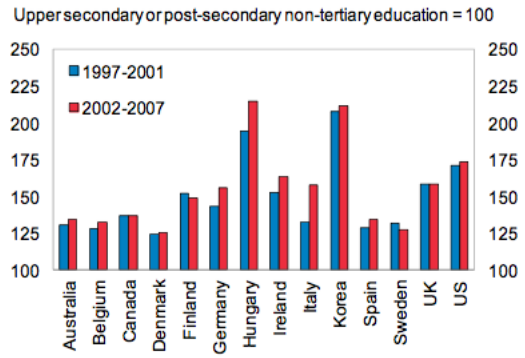

Figure 2.2: Skill Premium in Selected Economies.
Note: Skill premium measures the relative earnings from employment after completing tertiary education compared to the earnings after completing upper- and post-secondary non-tertiary education.
Sources: Organisation of Economic Co-operation and Development.

Over the past decades, it has reduced the cost of transportation, improved automation and communication, new markets have opened, bringing new growth opportunities in both rich and poor countries, with a lot of people lifted out of poverty.

Nevertheless, the main issue is what is the effect of technology on income inequality.

Income distribution is supposed to be altered by technological change over time both directly, with the effect on productivity, and indirectly with the rate of accumulation of factors of production.

Karni and Zilcha (1993) proposed a model combining intergenerational theories, like accumulated wealth, and intragenerational theories, determined by labour supply decisions. Their approach takes the stochastic process generating income inequality as given and just focus on the change in inequality resulting from the introduction of technological progress. Generally speaking the variation of income of an individual is determined by the inherited wealth as a result of conscientious decisions of the parents and by some idiosyncratic risks which represent the "pure luck" aspect. The effect of the intergenerational transfers on income inequality is mitigated by the endogenous labour supply decisions. The model suppose two periods, a working period in which individuals work, consume and save, and a retirement period with only consumption.

First of all, we make a distinctions about the different kinds of technological improvements. The Hicks-neutral technological progress exhibits an increase of the marginal productivity of all the factors of production, both labour and capital, in the same proportion. The Harrod-neutral technological progress assumes a constant marginal product of capital, while the marginal product of labour increases faster than the number of available workers. The

Solow-neutral technological improvement has a constant marginal product of labour.
There are different effects on income inequality.
The Hicks-neutral technological change doesn't affect the distribution of income during the period in which the change occurs, but for every period after the income inequality decreases. It will increase the capital-labour ratio in every period following its introduction.
The Harrod-neutral and the Solow-neutral technological improvement instead affect the income distribution as soon as they occur and their subsequent effect depends on the nature of the improvements, specifically on the elasticity of substitution in production.
In the same period of the introduction they both cause a decrease in the income inequality. Then the Harrod-neutral decrease the inequality if the elasticity is larger or equal to 1. The Solow neutral decrease it instead if it's smaller or equal to 1.
Up to now we assume unexpected technological change, but the same conclusions hold in case the improvements are anticipated. In this case the expected increase in income and interest rates will immediately create an increase in the savings, a subsequent increase in the aggregate capital prior to the implementation. This will result in an even lower income inequality.

Galor and Tsiddon (1997) introduced the concept of earnings mobility, analysing its relationship together with technological progress, wage inequality, and economic growth. Their paper shows that earnings mobility governs the rate of technological progress and economic growth while technological progress determines the pattern of wage inequality and intergenerational earnings mobility. They showed a kind of interplay between all this variables, following a repeating cycle, whose evidence appear also in the empirical data of US.
In periods of technological inventions individual ability plays the most important role, the relative importance of the initial parental conditions diminishes, mobility and inequality rises. This creates a larger concentration of human capital in the most advanced sectors, stimulating further technological progress and economic growth. So initially inventions increase the return to skills.
When the existing technologies become more widespread and accessible, the parents' endowment of human capital is the dominating factor, mobility diminishes, inequality decreases, even if it gets more persistent. Also the return to skill decreases.
Looking to the US economy data of last century, when exhibit a rapid rate of technological inventions and a subsequent productivity slowdown. The reason is the predicted productivity slowdown in the short run, after the technological progress, given the high human capital

requirement in the form of on-the-job training.
Finally, their study suggests that a society characterized by social impediments to mobility may cause a distorted allocation of talents across occupations, a lower rate of innovations so a lower economic growth. So we may conclude that social barriers for mobility bring about economic impediment.
Looking this issue from a different point of view, we can state that high ability individuals are attracted by high wage technologically advanced sectors. Supposing that ability is transmitted across generations, a low lever of mobility may reflect an efficient allocation of talents across different occupations.

Galor and Moav (2000) analysed the consequences of technological progress with respect to wage inequality, wage dispersion within different groups, quality of labour supply.
First, an increase in the rate of technological progress raises the return to skill and decreases in the unskilled one. There is a subsequent increase the supply of educated people which finally increases the level of human capital. This in turn will create new technological progress. This dynamic path permits a monotonic rise in wage inequality both within and between groups along the transition toward a new steady state.
If technological progress raises the relative return to skill, the wage inequality will increase both within and across groups. If instead it increases the return of education, without affecting ability, even low ability people will acquire a better education, the ability dispersion among educated will be higher, wage inequality will rise among skilled but decline among the unskilled which are still acquiring no education.
Technological progress is assumed to reduce the adaptability of the existing human capital for the new technological environment. Able individuals have a comparative advantage in adapting to the new situation, mostly because their learning cost is smaller, and that's why they succeed.
Specifically, individuals face three effects due to technological progress.
Their level of human capital is diminished after the transaction to a superior state of technology, for the so called "erosion effect". Each of them operates now with a superior technology, so they're more productive for the "productivity effect". Finally, the return to skilled increases but the threshold level of ability above which individuals decide to get skilled decreases. So for the "composition effect", the number of skilled increases and the unskilled one decreases.
For the erosion effect the Total Factor Productivity decreases in the short run, but, once the rate of technological progress reaches a new steady state, it remains constant while the productivity effect goes on growing.

Empirical data from US show there are episodes in which a decline in wage inequality is associated with increase in the fraction of skilled. This happens if we introduce the institutional changes into the basic model, which reduce the imperfections in the capital markets. That's why there's a dynamic process of evolution of wage inequality between skilled and unskilled, given a constant increase in the skilled labour supply and the evolution of institutional changes.

The paper by Gould, Moav and Weinberg (2001) studied the inequality growth in a different way, by incorporating the role of ability and adding a new component, the random depreciation rate of technology-specific human capital as another source of inequality. From this perspective the sources of inequality growth are different between educated and less educated workers: for the educated workers the increase in inequality is determined more by the changes in the composition and return to ability, while for the less educated ones randomness plays a prevalent role. Thus, inequality regarding the most educated workers increases mainly along more predictable "permanent" dimensions, as ability, while for the less educated ones it follows mostly random ways.
Their model is based on the disproportionate effect of technological change on the depreciation of general versus technology-specific skills. Specifically, individuals, given their level of ability, decide whether to invest in education, acquiring general skills, or receiving technology-specific skills through on-the-job training. Higher ability people decides for the education investment, given the higher return associated with it, lower ability ones choose instead the on-the-job training. Changes in technology render the technology-specific skills obsolete so high educated workers will suffer of an higher rate of human capital depreciation due to technological improvements. The final result is that the rate of technological progress increases the education premium.
Workers do not know in which sector their specific skills will depreciate more, therefore they choose their sector and level of education on the basis of the distribution of the rate of progress across sectors, and this creates an element of risk in the model. So there exists a precautionary element in the demand for education as workers consider both risk and return in their decision to invest in general education vs technology-specific skills.

Card and Di Nardo (2002), looking from an empirical point of view, addressed the increase of the rate of technological progress mainly to the development of the microcomputers, seen as complementary to human capital for the highly skilled workers. The biggest changes associated with the computer revolution are the organization-related tasks, so the evolution

of the network technology is as important as the PC one.
Computers, according to their analysis, increase the productivity of the skilled workers. The subsequent wage gap produced by a higher difference in the level of productivity creates the rise of inequality.

The model of the interplay between the international trade and the role of technology inside it was studied by Krugman (1979). Technological progress takes the form of development of new products with the subsequent substitution of the old ones. He postulated a world of just two countries, the innovating North and the non innovating South. The new products, result of the innovation, are immediately produced in the North, and later also in the South, once they're exported there, thanks to trade. The model approaches to a moving equilibrium in which North exports new product and imports the old ones. Labour is equally productive in both the regions but wages are higher in the North due to its monopoly position. Only a slowing of innovation or an acceleration of technology transfer narrows the wage differential, fact that could force the North to start protectionist actions.
To conclude, according to Krugman, technology increases inequality, creating monopoly mark-ups, difficult to eliminate without forcing the innovator country to adopt protectionist actions, negative from the efficiency point of view.

Redistributive Policies to counteract Inequality

Even if following different patterns, technological change has a positive impact of the rise of inequality. This may be seen as a kind of paradox: the engine of our economy not only is unable to solve the biggest problem societies ever faced, but is also directly proportional to it. The question is now whether an institutional solution, able to mediate this phenomenon, exists.
Government in advanced economies have historically mitigated the rise of inequality through the adaptation of adequate public policies, as progressive taxes, social transfers like public retirement benefits. The nature of appropriate policies has to vary across countries, taking into account institutional settings and capacity and implementation constraints. The redistributive role of the fiscal policy could also create more public reliance on property taxes, progressive income taxation, removing the opportunity for tax avoidance and evasion. Better targeting of social benefits would also minimize the efficiency cost, in terms of incentive to work and to save.
Especially in developing countries, education policies may be the right tool to solve this

problem, as cash transfer to promote a more equal access to school, or public spending on education that benefits specifically the poor. This solution may decrease the dependence on socio-economic circumstances that educational opportunities face, facilitating the accumulation of human capital, and consequently reducing inequality. Anyway, the effect of increased educational attainment on income inequality strongly depend on the evolution of rates of return to education, influenced by the size of the investment of individuals and government on it.

Robert Barro (1998) produced an empirical work aimed to isolate the specific effect of policies, using a panel data regression. He analysed an heterogeneous sample of countries, belonging to different economic development classifications, to estimate the effects of alternative government policies on the long-term growth. Doing this he faced the problem of reverse causality, as much of the governments' behaviour can be interpreted as a reaction to the economic events. He wanted to show how institutions like nation's basic political, legal and economic ones typically remain stable in the short run, so have little impact on recent boom or recession. The long-lasting differences in these institutions across different countries, instead, are empirically the most important determinants for the rate of economic growth and investments.
To demonstrate this he evaluated the growth rate of per capita output Dy as a function of the current level of the per capita output y and of the long run level of per capita output y*. In this model, a permanent improvement in some government policy first raises Dy, and then, gradually over time, also y increases. So on the long run the impact is only on the level of per capita output, not on its growth rate.
The empirical evidence doesn't show any pattern of absolute convergence, according to which poor countries grow faster than the rich ones, but does demonstrate evidence for a conditional one. For example, very low level of GDP countries grow fasted for given values of policies or other explanatory variables.
Making a parallelism with the inequality, the improvement in some policies should decrease the growth rate of inequality and then, over time, decrease the current value of inequality. Obviously more details are needed to state such a conclusion.

Redistributive policies must have costs, due to distortions in agents' effort or saving decisions. They also have benefits, due to the imperfections in asset markets they are able to partially solve; redistribution then provides both insurance and a means to relax on constraints that could impede investments. Roland Bénabou (2002) analysed the different effects that taxes

and transfers and progressive education finance have on income growth. Both are equally effective at substituting for the missing credit market, but the latter creates smaller distortions to labour supply and savings, given that it redistributes only a fraction of family income. So, progressive education finance always leads to higher income growth, at the cost of lower consumption insurance. The aggregate efficiency is shown to be maximized at some strictly positive rate of redistribution, depending on parameters like the labour supply elasticity, the variability of idiosyncratic shocks and the growth losses from liquidity-constrained investments.

The model demonstrated the long run growth to be maximized when the average marginal and tax-and-transfer rate equals 21%, leading to a redistributive transfer of GDP of 6%. Taking into account the value of insurance and leisure, the maximization of aggregate efficiency raises these numbers to 48% and 14% respectively. Under the alternative policy of progressive education finance, the growth-maximizing equalization rate for school expenditures is 62%, the efficient one 68%. In both cases, the efficient policy results in the top 30% of families subsidizing the bottom 70%, whether through the fiscal or the education system.

In $Table 2.1$ [1] are reported the average marginal tax rates of OECD countries, computed using the tax data of 2015. Data are reported in percentage.

[1] Source: OECD Tax Database: Table I.4 dataset

Table 2.1

State	*Avarage Marginal Tax Rate*
Australia	29.3
Austria	49.7
Belgium	56.0
Canada	31.0
Chile	7.3
Czech Republic	43.0
Denmark	38.0
Estonia	39.1
Finland	44.9
France	49.8
Germany	49.2
Greece	41.0
Hungary	49.0
Iceland	34.6
Ireland	30.6
Israel	23.3
Italy	49.5
Japan	32.9
Korea	21.9
Luxembourg	39.3
Mexico	19.7
Netherlands	36.9
New Zeland	18.8
Norway	38.2
Poland	34.8
Portugal	42.8
Slovak Republic	41.6
Slovenia	43.1
Spain	40.5
Sweden	45.4
Switzerland	23.3
Turkey	39.2
United Kingdom	32.1
United States	33.1

Ferreira (1999) introduces the “median voter theorem” to link the level of inequality with the choose of the tax rate. The theorem states that if:

i) Preferences for some such policy variable (say: a proportional tax rate) vary monotonically across the distribution of some attribute of the population (say, their incomes)
ii) Each person has one vote (with equal weight)

Then the preference of the voter which occupies the median position in that distribution will be the outcome of the voting process. Now, if the government is such that the net effect of its taxation and expenditure policies is redistributive, then it is easy to show that preferences for the value of decline monotonically with income. And if one measures inequality as the distance between the median and the mean voter, then for a given mean income, it follows that greater inequality leads to the choice of a higher tax rate.
Adding to this result any distortionary effect of taxation, such as a disincentive to effort, or to save, the model shows how greater inequality leads to lower growth, as the graph below illustrates.

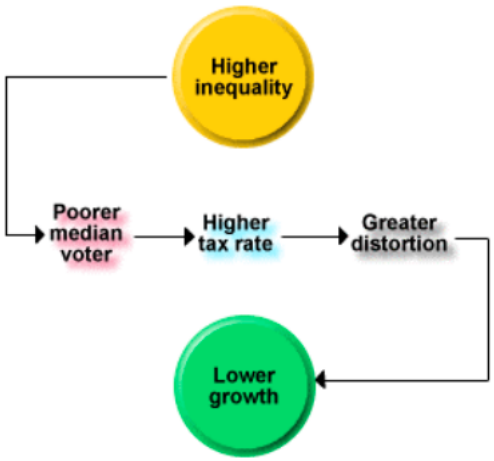

Figure 2.3: Median Voter Theorem.

Sources: Inequality and Economic Performance, by Francisco Ferreira.

3

Empirical Evidence: The Econometric Study

The Econometric Model and the Purpose of the Study

This paper wants to show how inequality is affected by growth, specifically by the GDP growth rate, and how the relationship between these variables changes across countries. Specifically, interaction variables between the GDP growth rate and some geographical areas dummies allow to estimate the different effect growth exhibits on inequality. Finally, the percentage of Investment spent on ICT is used as a measure of the technological progress; the model wants to show how inequality changes due to this technological progress. Also in this case some interaction variables are used to evaluate the effect technological progress has on inequality, given different geographical areas.

To isolate the effect of growth on inequality, some economic variables are introduced. They are: the degree of openness of a country's economy and the government spending. The GDP value is used under the natural logarithm function. The inequality indicator used is the Gini coefficient.

Furthermore, it's also necessary to isolate each country intrinsic characteristic, controlling for unobservable variables that change from one country to another, but remain fixed over time. So the panel data estimation has been implemented by the country fixed effect dummy variables. They minimize the omitted variable bias, due to all factors which affect the economic growth of a country over time but are difficult to measure. Examples are climate, culture, geographical area and resources.

The distortions crated by the time effect only, but fixed over states, like economic downturn or a supply oil shock, are eliminated by the time fixed effect dummy variables. This set of dummy variables has the objective to minimize the omitted variable bias of the panel data.

To estimate the interaction effect between the GDP growth rate or ICT investment and

some specific states, four macro geographic area groups are created, each one containing countries of similar culture, tradition and economic background. The controlled group is the Anglo-Saxon one.
The program used to compute all the statistics is Stata 13.0.
The linear regressions are obtained with the use of the command reg and the robust standard error is implemented.

Data Description

The dataset used is a merge of two datasets: the OECD Factbook Dataset for the ICT investment measures and the Penn World Table for all the other variables.
For the regressions not containing the ICT investment variable, reg 1 and reg 4, there is an highest number of observations, the time period is a 48 year one, fro 1960 till 2008, and there are 24 states analysed. In reg 2, reg 3, reg 5 and reg 6, instead, 15 countries are analysed, for a 15 year time period, from 1985 till 2000. This is due to a lack of information regarding the ICT investment measurements.
The countries are lately divided in 4 macro geographic area groups:

i) Australia, Canada, Ireland,New Zeland, United Kingdom and Unites States for the Anglo-Saxon group.
ii) Austria, Belgium, France, Germany, Greece, Italy and Luxembourg for the European group.
iii) Denmark, Finland, Netherlands, Norway and Sweden, for the Nordic group.
iv) Hong Kong, India, Japan, Republic of Korea, Singapore and Taiwan for the Asian group.

The depend variable $ineq$ is measured by the GINI index. It is expressed in integer numbers, so it takes values between 0 and 100. The inequality variable as a mean of 34.8. Particularly high values of inequality are registered in India, Greece, Singapore and Korea. Under the inequality average there are instead mostly the Nordic countries togheter with Germany and Netherlands.
The gdp_{growth} is computed as gdp_{growth} = ln(gdp_n) - ln(gdp_{n-1}).It has a 0.0678 mean, particularly high valued are registered for the Asian group, exception done for Japan, who has characteristics similar to the European group members.
The ict_{inv} is the percentage of investment spent on Information and Communication Technology, mean of 15.6. The United States value is the highest, more than 10 points bigger than the average. In general the Anglo-Saxon group performs pretty well in this field.

The GDP is calculated under the natural logarithm function, is the real value measured in current prices and used also to compute the gdp_{growth}. The $ln(gdp)$ has a mean of 8.9 with a very low standard deviation for all the countries. Luxembourg has the highest value.
The $openk$ measures the degree of openness of a country economy, has a mean of 70.74. It's the ratio of exports plus import over GDP, so it reports the total trade as a percentage of GDP. The smallest countries exhibits the highest level, as for Singapore, Hong Kong, Luxembourg and Belgium.
The government spending, cg, is written as a percentage of GDP, with a mean of 14.2. India and Sweden have the highest value while Singapore and Hong Kong the lowest.
The interaction variables $growth\_eu$, $growth\_asia$, $growth\_nord$ have the role of estimating the specific effect of the gdp growth has on inequality for different countries groups.
The same holds for the interaction variables ict_eu, ict_asia, ict_nord, created to estimate the specific effect that technological progress has on inequality for different countries groups.
The Anglo-Saxon group is used as the control group.
$Figure$ 3.1 and $figure$ 3.2 are scatter plots to show the correlation, respectively, between ICT investment and inequality and GDP growth inequality.
Specifically, ICT investments and inequality are negatively correlated, with a coefficient equal to -0.255. This means the technological progress decreases inequality. It's module is quite lower for the US and Korea while it's quite bigger for Sweden and Finland.
GDP growth and inequality are instead positively correlated, meaning the GINI index increases with a country increase of GDP value. The coefficient is about 48, but the standard error is even bigger, suggesting a serious problem of omitted variable bias. India and Greece have the highest coefficient while Sweden and Taiwan the lowest.

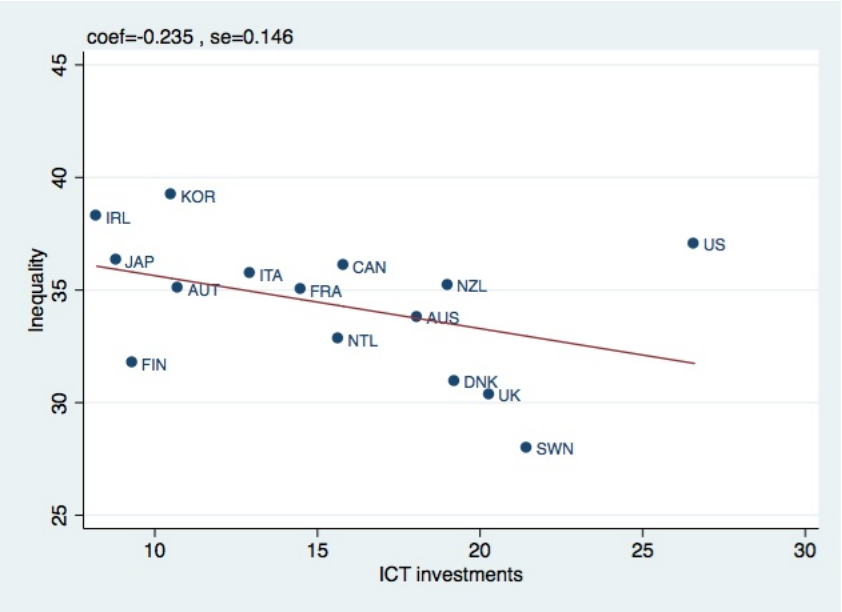

Figure 3.1: Correlation between ICT Investments and Inequality

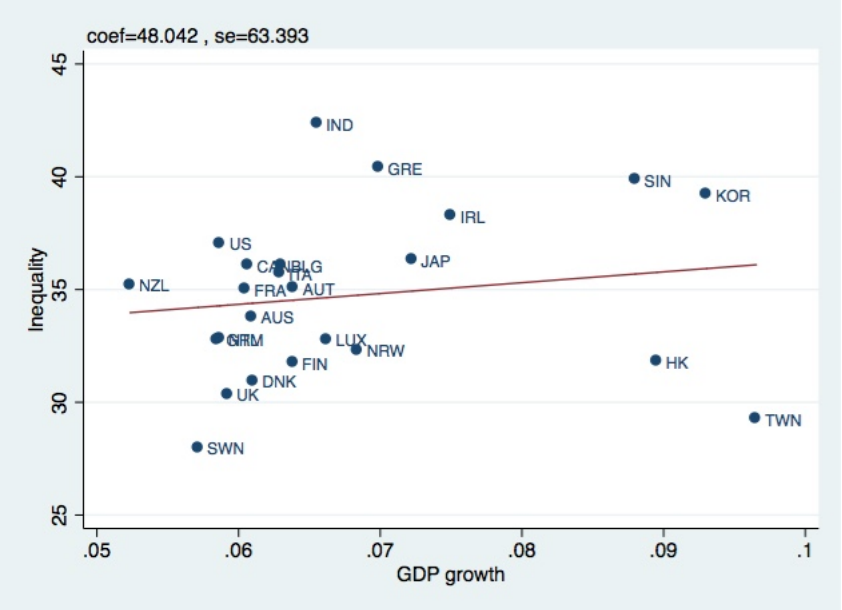

Figure 3.2: Correlation between GDP growth and Inequality

Table 3.1: Descriptive Statistics

	ineq	gdp_{growth}	ict_{inv}	ln(gdp)	openk	cg
Australia	33.781	0.061	18.076	9.208	27.559	12.764
Austria	35.055	0.064	10.744	9.234	59.012	13.031
Belgium	36.057	0.063		9.190	113.577	15.537
Canada	36.067	0.061	15.806	9.258	49.033	15.080
Denmark	30.950	0.061	19.236	9.198	54.520	18.345
Finland	31.724	0.064	9.312	9.084	45.273	16.790
France	35.008	0.060	14.500	9.153	31.006	16.308
Germany	32.774	0.059		9.545	44.062	13.245
Greece	40.415	0.070		8.869	31.878	13.420
Hong Kong	31.803	0.090		8.967	179.672	4.202
India	42.352	0.066		6.738	21.982	25.081
Ireland	38.260	0.075	8.219	8.935	77.248	11.775
Italy	35.730	0.063	12.931	9.085	37.158	13.116
Japan	36.329	0.072	8.822	9.112	15.722	12.154
Korea, Republic of	39.207	0.093	10.525	8.146	33.641	13.078
Luxembourg	32.781	0.066		9.756	207.743	8.463
Netherlands	32.821	0.059	15.656	9.267	75.650	16.965
New Zealand	35.209	0.052	19.007	9.019	39.197	15.068
Norway	32.304	0.068		9.353	60.788	14.259
Singapore	39.883	0.088		8.841	311.451	6.378
Sweden	27.979	0.057	21.456	9.246	53.710	21.923
Taiwan	29.277	0.097		8.264	71.685	15.059
United Kingdom	30.349	0.059	20.288	9.109	35.474	18.062
United States	37.047	0.059	26.588	9.476	15.371	11.090

Estimation of the Results

The first linear regression computed, *reg 1*, wants to estimate the effect that gdp_{growth} has on inequality, controlling for country and time fixed effects. *Reg 1* is the following:

$$ineq = \beta 1 gdp_{growth} + \beta 2 ln(cgdp) + \beta 3 openk + \beta 4 cg + c_i + \lambda_i + \epsilon_{it} \tag{3.1}$$

GDP growth has a positive effect on inequality and it's statistically significant at 10% significance level. Specifically, if the GDP growth increases by 1 percentage point, ceteris paribus, the inequality increases by 5.1.
The GDP has instead a negative effect, highly significant, suggesting that the increase of GDP creates a lower value of inequality than the increase in the GDP growth rate.
The openk coefficient is statistically significant at 1 % significance level and it's positive, even if not so high in value. Ceteris paribus, with an increase of 1 percentage point of openk, the inequality increases by 0.03.
Finally, the cg coefficient is slighly negative but not significant.
In the second regression, *reg 2*, the ict_{inv} variable is introduced, to estimate the effect technological progress has on inequality. We control for country and time fixed effects.
Reg 2 is the following:

$$ineq = \beta 1 ict_{investment} + \beta 2 ln(cgdp) + \beta 3 openk + \beta 4 cg + c_i + \lambda_i + \epsilon_{it} \tag{3.2}$$

The number of observation gets now quite lower, since the ict_{inv} measurement is limited to a relatively short amount of countries. Specifically, there are 15 countries while the time period is a 15 year one.
The ICT investment coefficient is positive and significant at 10% significance level. Ceteris paribus, an increase of ICT investment by 1 percentage point increases the inequality by about 0.1.
The gdp coefficient is not significant anymore, still negative but quite lower.
The openk and cg coefficients signs remain the same and their values don't change in a consistent way.
The third regression, *reg 3*, contains both the gdp_{growth} and ict_{inv} variables and is the

following:

$$ineq = \beta 1 ict_{investment} + \beta 2 gdp_{growth} + \beta 3 ln(cgdp) + \beta 4 openk + \beta 5 cg + c_i + \lambda_i + \epsilon_{it} \quad (3.3)$$

The number of observations, the countries and the time period are the same of *reg 2*.
Neither the GDP growth nor the ICT investment variables are significant, and they both mantain the sign of the previous regressions.
Ceteris paribus, a 1 percentage increase in GDP growth increases inequality by about 6. The standard error is quite big, about two third of the coefficient estimated.
A 1 percentage increase in ICT investment increases the inequality, ceteris paribus, by about 0.08.
The GDP coefficient is negative and not significant; it gets less than half in module than the previous estimations.
The openk coefficient remains pretty the same and it's significant.
Finally the cg one gets now positive but not significant.
In the regressions that follows, the geographic group dummies are introduced together with some interaction variables to estimate the specific effect of GDP growth, in *reg 4* and *reg 6*, and ICT investment, in *reg 5* and *reg 6*, have on inequality for the different states groups.
Reg 4 is:

$$ineq = \beta 1 gdp_{growth} + \beta 2 growth_{nord} + \beta 3 growth_{eu} + \beta 4 growth_{asia} + \quad (3.4)$$

$$\beta 5 ln(gdp) + \beta 6 openk + \beta 7 cg + c_i + \lambda_i + \epsilon_{it} \quad (3.5)$$

The GDP growth variables gets now quite lower, even if still positive, not significant and with a huge standard error. Ceteris paribus, a 1 percentage increase in GDP growth increases inequality by 1 point.
Analysing the interaction variables between growth and states groups, both the Nordic and European countries interactions are statistically significant at 1% significance level. They are both positive, meaning that the effect growth has on inequality is bigger for them than for the control group, the Anglo-Saxon one.
The Asian one in negative, even if not significant, so its effect is lower than the control group one. Its module of the interaction is bigger than the GDP growth one, so for the Asian

countries the relationship changes in sign, the GDP growth decreases inequality. Anyhow, the standard error is double the module of the coefficient, suggesting a very high volatility. All the other coefficient, but for the government spending, are 1% significant. An increase in both the GDP and the government spending negatively affect inequality ceteris paribus. An increase in openness, instead, increases the inequality.

In *reg 5* the interaction variables between ICT investment and the states groups are used.

Reg 5 is:

$$ineq = \beta 1 ict_{investment} + \beta 2 ict_{nord} + \beta 3 ict_{eu} + \beta 4 ict_{asia} + \tag{3.6}$$

$$\beta 5 ln(gdp) + \beta 6 openk + \beta 7 cg + c_i + \lambda_i + \epsilon_{it} \tag{3.7}$$

The ICT investment variable is highly significant and positive. Specifically, ceteris paribus, a 1 percentage increase in ICT investments increase the inequality by 0.2.

All the three interaction variables are negative but only the Nordic countries one is significant. This means technological progress increase inequality the most in the Anglo-Saxon countries. For the other states the relationship, even if smaller in module, remains positive. The lowest increase in inequality due to the technological progress seems to be in the Nordic countries.

The GDP coefficient is not significant anymore, it remains negative even if smaller in module.

The openk coefficient increases in module and it's still significant.

The cg coefficinet remains pretty the same as in *reg 4*.

Finally *reg 6* gathers all the interaction variables and both the GDP growth and ICT investment ones.

Reg 6 is:

$$ineq = \beta 1 gdp_{growth} + \beta 2 growth_{nord} + \beta 3 growth_{eu} + \beta 4 growth_{asia} + \tag{3.8}$$

$$+\beta 5 ict_{investment} + \beta 6 ict_{nord} + \beta 7 ict_{eu} + \beta 8 ict_{asia} + \tag{3.9}$$

$$+\beta 9 ln(gdp) + \beta 10 openk + \beta 11 cg + c_i + \lambda_i + \epsilon_{it} \tag{3.10}$$

Both the GDP growth and the ICT investment coefficients are now statistically significant, the first at 5% and the latter at 1 % significance level. They are both positive.

Ceteris paribus, a 1 percentage increase in the GDP growth rate increases the inequality by

about 11 points.

A 1 percentage increase in ICT investment, ceteris paribus, increases inequality by 0.2.

Analysing the growth interactions coefficients, no one of them is significant. The Nordic one is the only one negative, suggesting the growth has a lowest effect on inequality in this countries. Anyway, the GDP growth total effect still remains positive. The Asian countries one is the highest, and the GDP effect on inequality gets more then half higher in these countries. The standard error is quite high in this case. Finally the European countries one is the lowest in module, it's positive but with a huge standard error.

The ICT interactions coefficients are all negative and only the Nordic countries one is significant. This means technological progress increases inequality the most in the Anglo-Saxon countries. For the Nordic countries the ICT coefficient changes sign, becoming slighly negative. So in these countries the technological progress decreases the inequality.

Both the GDP and the openk coefficients are similar to the *reg 5* ones, while the government spending one is now higher in module and positive, but not significant.

Table 3.2: Reg1 & Reg2 & Reg3

	Dependent variable:		
	ineq		
	(1)	(2)	(3)
gdp_{growth}	5.187^{*} (2.770)		6.089 (4.276)
$ict_{investment}$		0.0934^{*} (0.0552)	0.0837 (.0579)
ln(gdp)	-6.403^{***} (0.680)	-0.565 (1.591)	-0.257 (1.603)
openk	0.0355^{***} (0.106)	0.0692^{***} (0.0182)	0.0635^{***} (0.0180)
cg	-0.0259 (0.089)	-0.0896 (0.136)	0.0319 (0.178)
Constant	95.080^{***} (7.711)	40.743^{**} (17.556)	36.723^{**} (17.732)
Observations	850	230	230
Country Dummies	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes
Residual Std. Error	2.0468	1.1422	1.1386
F Statistic	79.35^{***} (df = 66; 783)	99.19^{***} (df = 34; 195)	95.73^{***} (df = 35; 194)

Table 3.3: Reg4 & Reg5 & Reg6

	Dependent variable:		
	ineq		
	(1)	(2)	(3)
gdp_{growth}	1.057 (2.685)		10.793^{**} (4.626)
growth_{nord}	11.369^{***} (3.768)		-8.805 (5.595)
growth_{eu}	12.474^{***} (3.314)		1.263 (11.487)
growth_{asia}	-3.675 (6.264)		6.454 (8.859)
ict_{inv}		0.217^{***} (0.0603)	0.211^{***} (0.0638)
ict_{nord}		-0.259^{***} (0.0500)	-0.269^{***} (0.0505)
ict_{eu}		-0.105 (0.0722)	-0.118 (0.0808)
ict_{asia}		-0.172 (0.281)	-0.108 (0.283)
ln(gdp)	-6.773^{***} (0.680)	-2.145 (1.446)	-1.493 (1.552)
openk	0.0349^{***} (0.00621)	0.0876^{***} (0.0170)	0.0769^{***} (0.0170)
cg	-0.0297 (0.0908)	-0.0330 (0.130)	0.110 (0.164)
Constant	98.361^{***} (7.761)	56.011^{***} (14.910)	46.914^{***} (15.815)
Observations	850	230	230
Country Dummies	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes
Residual Std. Error	2.0334	1.0797	1.0698
F Statistic	74.91^{***} (df = 69; 780)	115.93^{***} (df = 37; 192)	119.42^{***} (df = 41; 188)

Note: *p<0.1; **p<0.05; ***p<0.01

Nordic Countries = Denmark, Finland, Netherlands, Norway, Sweden
Asian Countries = Hong Kong, India, Japan, Republic of Korea, Singapore, Taiwan
The inclusion of Japan in the Asian group doesn't significantly change its coefficients
European Countries = Austria, Belgium, France, Germany, Greece, Italy, Luxembourg, Spain

4

Conclusions

The main findings of this paper is that both the increase in GDP growth rate and the increase in technological progress positively affect the level of inequality.

The two variables have significant coefficients once we gather both of them in *reg 6*, together with their interaction variables.

The increase in GDP growth effect is quite bigger, since a 1 percentage increase of its value, ceteris paribus, increases inequality by about 11 points, more than two times its standard deviation. This is true for the Anglo-Saxon countries, that constitute the control group. Analysing the interaction variables coefficients of the other groups with the GDP growth, no sure conclusions can be stated since none of them is significant. The Nordic countries interaction variable is the only one negative, meaning the effect the increase in GDP growth has on inequality is the lowest for this states group. The Asian countries one is the highest, so the GDP growth affects inequality the most for these countries. Finally the European countries interaction coefficient is quite low in module, suggesting they behave in a similar way as the control group.

The increase in ICT investment effect is lower, meaning change in technological progress has a lower effect on inequality than the GDP growth one. Specifically, a 1 percentage increase in ICT investment, ceteris paribus, increases inequality by 0.2, that's one twentieth of its standard deviation. Again, this holds for the Anglo-Saxon countries. The interaction variables coefficients are all negative and only the Nordic one is significant. This mean the increase technological progress affects inequality the most in the control group. The lowest effect is registered for the Nordic countries, whose interaction coefficient is significant at 1% significance level. For these countries the entire effect of the increase in ICT investment changes in sign, becoming slightly negative. In conclusion, ceteris paribus, inequality decreases given an increase in the technological progress for the Nordic countries.

Evidence demonstrated Denmark, Finland, Netherlands, Norway and Sweden are the most

equal countries. This is probably the consequence of efficient redistributive schemes, which allow a consistent part of the population to enjoy the technological progress and the GDP growth. These countries have historically high education standards, although education is mostly free of charge. The human capital creation engine is probably the key of their success.

Further studies may check for possible omitted variable bias, so for those factors which are correlated with the independent variables and at the same time determine the dependent one. This could be the case of the black market, or underground economy, that part of the market characterized by some form of noncompliant behavior with an institutional set of rules. For sure it is correlated with the GDP of a country and with its growth, and it definitively determines the its GINI level. Once controlling for this new variable, new results may be found. Obviously an efficient instrumental variable to check for it has to be found.

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