Technology and Inequality: Empirical Evidence from a Selection of OECD Countries

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Abstract

Kuznets suggested that economic progress, in the early stages of the industrialization, is accompanied by increasing inequality, but that these disparities tend to disappear as the industrialization process deepens and the benefits of development are more widely distributed. This conjecture is inconsistent with observed patterns of inequality in the 1970s and 1980s. This paper examines the dynamics of inequality across OECD countries over the 1970-1990 period, presenting and assessing the dominant explanations in the literature. It is suggested that an augmented Kuznets curve in which the evolution of the relationship between growth and inequality for highly developed countries no longer exhibit the negative relationship between growth and inequality, is consistent with recent empirical observations.

1. Introduction

Until recently, technology and inequality were two rather disconnected concepts, with technology belonging to the realm of the developed world, where it is considered the main engine of growth, and with inequality being fundamentally a problem of developing countries, only marginally important in developed countries, as Conceição and Galbraith [1] argue[1]. This situation has changed considerably in recent years. The motivation behind this development owes much to the increase in the dispersion in income inequality observed from the early 1970s in the US [2] and from the late 1970s in the UK [3]. The maybe-surprising fact is that technology, which has been credited for driving growth and prosperity, came equally to be blamed for this observed increase in inequality in developed countries.

In fact, there has been a rapid but largely *ad hoc* convergence towards a consensus that technology is to be blamed for increasing inequality [4]. The main assumption is that technological change is (or has become) *skill-biased*, in the sense that it creates jobs that demand people with high skills. The mechanism through which technology conduces to inequality depends on the assumption that technologically driven increases in demand for highly skilled labor lead to a higher wage for highly skilled workers in comparison with non-skilled labor.

During the period of sustained growth of the 1950s and 1960s, the conventional view was that there was a complementarity between technology and aggregate labor. If the skill-biased technological change hypothesis is valid, this era ended, giving way to an age of complementarity between technology and skill. Therefore, the question that arises is, when did skill-biased technological change emerge, and what were the causes of that emergence? Digital computers and, more generically, information technologies, are widely considered the "trend breaking technology" that is responsible for this development [5].

Yet, despite its surface plausibility, the skill-biased technological change hypothesis has faced considerable empirical and conceptual difficulties. Galbraith [6] provides a thorough analysis of the main empirical criticisms. One major issue is associated with the mismatch between the timing of the diffusion of information technology, and the start the increase in inequality, namely in the US. Howell [7] provides an equally critical assessment of the empirical validation of the skill-biased technological change hypothesis. Another major problem is related with the fact that computers and information technology in general do not seem to have contributed to increases in productivity [6]. In fact, productivity growth has been stagnant at levels much lower than the records set in the two decades that followed World War II. If the motivation to higher highly educated people that can work with computers, aiming at increasing productivity (from which the age premium must come), why do not we see an increase in productivity? A standard answer from students of the process of technological change [8] is that new

[1] This paper draws heavily from [1].

technologies, especially those that are broadly applicable and have a high potential impact, take a long time to make their effects be felt economically. But then, their effects should not also be seen in the labor market.

On the conceptual side, a large amount of scholarship on the process of technological change has largely been ignored. In fact, typically, technology is conceptualized as an exogenous flow of innovations and as a purely public good, freely and universally available, as in the initial neoclassical models of Solow. This simplified treatment of technology comes at time when there is growing vitality in the study of technology and its micro and macroeconomic context. Several economists and other social scientists have fought the tendency to oversimplify the impact of technology, providing sophisticated conceptual and empirical insights into the way that technology is related with economic growth[9].

Thus, in conclusion, dominant explanations for the patterns of inequality evolution in developed countries are centered in single-country, longitudinal studies based on labor market/human capital analysis. In terms of the ultimate causes of inequality, technological change has been the primary culprit. Most of the proposals advancing the skill biased technological-change hypothesis do it without adequately measuring technology or the pace of technological change. Studies asserting a causal association between computer usage and wage levels have been categorically refuted. This proposition runs into a host of empirical problems, such as the mismatch in the timing of the increase in inequality and the introduction of computers, and the fact that the increased adoption of information technology has not noticeably contributed to increased productivity. Beyond these problems, most studies ignore the large scholarship associated with the relationship between technology and the economy, and also the tradition of macroeconomic studies associating inequality with macroeconomic fundamentals, in the tradition of the Kuznets hypothesis and the macro-determinacy of inequality.

2. Growth, Inequality, and the Kuznets Hypothesis

The origins of the relationship between income distribution and growth go back to Keynes, who was concerned with the effect of income distribution on aggregate demand, through the asymmetric consumption and saving behavior of individuals with different personal levels of income.

The Kuznets [10] conjecture followed the Keynesian tradition, becoming the most influential income distribution theory of this early Keynesian period linking growth and inequality. Essentially, the Kuznets hypothesis states that there is a causal relationship running from growth to inequality. Figure 1 illustrates the way Kuznets arrived to his hypothesis. Suppose that there is a country that departs from an initial stage where the growth is the same for both the low and the high-income shares of the population. Total income is also grows at the same rate, but difference between the high and the low-income groups of the population is constant; thus, inequality does not change as income grows in this initial stage.

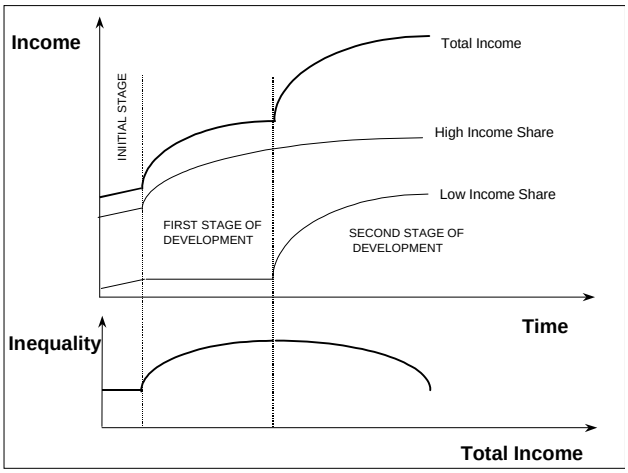

Figure 1: The Kuznets hypothesis.

Now assume that there is a first a first stage of development where the income of the high-income share of the population starts rising more rapidly than the low-income group. This can correspond to a shift from a traditional and stable agricultural society to an industrialized urban economy. People with the high-income shift from the traditional rural sectors to the more productive industrial new sectors, thus gaining in income. In this first stage of development, growth in income is accompanied by increased inequality. In a second stage of development, as total income rises and the process of industrialization deepens and broadens, the low-income group starts to catch-up. And since it departs from a much lower level of income, growth is more rapid than for the high-income sector. In this second stage of development, growth leads to decreasing inequality.

A more modern treatment of the Kuznets hypothesis is included in Galor and Tsiddon [11], who develop a general equilibrium model in which growth and inequality are both endogenous. The inverted-U arises due to imperfections in the capital market, but the diagram in Figure 2 is as useful as before to illustrate the dynamics according to this new mechanism. The high income and the low-income groups have different patterns of investment, which, in the initial stages of development, benefit mainly the high-income group. Capital market imperfections make it difficult for the poor to borrow, since the imperfection is characterized by free lending, but borrowing requires collateral, which the poor do not possess. This dynamic generates growing inequality, which can persist or can disappear depending on parameter values. In Galor and Tsiddon, investment-led

growth creates new opportunities for the poor, who have more chances of borrowing with higher returns than for the high-income group.

In these models the persistence of inequality is harmful for growth because it leads to a sub-optimal level of investment. This causal relationship from inequality to growth can be considered an evolution of the Kuznets hypothesis, and has received a great deal of attention in the recent literature on the macroeconomics of inequality. In fact, several empirical studies argue that there is a systematically negative relationship between inequality and growth [12].

The hypothesis of a negative relationship between inequality and growth has also motivated a large theoretical effort to propose models that can account for mechanisms through which inequality hampers growth. One stream of scholarship corresponds to endogenous models of growth and inequality with non-convexities that generate inequality.

A second type of model argues that inequality can generate sociopolitical instability. An unequal distribution of income can generate pressures and opportunities for violence (assassinations or coups), corruption, and other destabilizing factors that hinder growth by increasing uncertainty, disrupting investment and production, and undermining government policies. One example include is [12].

A third category of theories attempts to link political outcomes with inequality. More inequality can lead the voters to elect governments with more redistributive policies, where taxation is sub-optimal discouraging effort and investment, therefore slowing economic growth. In [12] there is a model along these lines.

Despite this growing interest in the relationship between growth and inequality, recent work by Li, Squire and Zou [13] question the existence of any systematic relationship between growth and inequality. Using the data set of Deininger and Squire [14], these authors specify different regression models with which they propose to test several of the hypotheses discussed above. First, with a panel regression with country dummies, they find no systematic relationship between income distribution and growth, but they do find a negative correlation between land distribution and growth. Using this result, they specify another model in which a dummy is used to differentiate democratic from undemocratic countries. The aim is to test the importance of the political system in mediating the dynamics of the relationship between growth and inequality: in principle democracies should be more responsive to demands of redistribution and therefore less efficient. The authors find that the dummy is not statistically significant, weakening the politically based explanation. Li, Squire and Zou [13] connect this result to the capital-market-imperfection hypothesis.

Still, the Kuznets hypothesis continues to generate considerable interest. However, it clearly does not appear to fit the patterns of the evolution of inequality in most of the OECD countries. Of course, this does not necessarily mean the Kuznets hypothesis is wrong. It may have been valid to explain the dynamics of most countries during a certain period of their economic progress. Thus, Ram [15] finds for the developed countries a U-shaped relationship between inequality and growth, a hypothesis that Harrison and Harrison Bluestone [16] had already proposed for the US in the late 1980s. Another development consists in using measures of economic progress that go beyond income per-capita [17].

But the major obstacle to persuasively testing the Kuznets hypothesis is associated with the data available to measure inequality. In the forthcoming sections, we analyzing the mostly commonly used data set on inequality, the Deininger and Squire data-set – recently made available under the auspices of the World Bank – and show the inadequacies of these measures of inequality. Instead, we propose a new data set, and provide a new look at the relationship between inequality and level of development both for developed and developing countries.

3. Patterns of Inequality Evolution in the OECD

Despite the difficulties with currently available data sets on inequality, many authors have offered analyses of the patterns of evolution in inequality in the OECD in broad strokes. The most commonly used aggregate measure of inequality is the Gini coefficient. This measure is a number between zero and one (or one hundred, depending on how it is defined) that summarizes the concentration of income (zero corresponding to total equality, one or one hundred to having all the income concentrated in a single individual). Normally Gini coefficients are computed from household surveys.

Concerning the source of data there are two main options. One is to use national sources, which typically provide many inequality estimates, but with a wide variation in coverage, methods and accuracy. Alternatively one can use international data sets based on comparable definitions and methods. Given the compatibility restrictions, these sources typically provide fewer data points over time for each country. As an initial approximation, we will use the data compiled by Deininger and Squire [14] under the auspices of the World Bank. This data set is considered the most thorough and largest source of internationally comparable measures of inequality, and has been the inspiration for many recent papers.

The Deininger and Squire data set is rather incomplete in terms of country coverage over time. Looking only at the OECD countries available in the data set from 1969 to 1992, the average number of data points per country is nine, with a standard deviation of six. The data set contains significant holes. Additionally, the values reported by Deininger and Squire are highly inconsistent with other sources. Differences between values from different sources are to be expected, given the sensitivity of the Gini measure, and inequality measures in general, to definition and methods of measurement. However, in cases where there is a large difference between the value from Deininger and Squire and values widely consistent across alternative sources, the results from the Deininger and Squire data set must be questioned. For the Nordic countries, in particular, the values reported in Deininger and Squire tend to be 10 points higher than the consensus obtained from other sources [1].

These comparisons illustrate the wide divergence in terms of coverage and values reported of widely accepted measures such as the Gini coefficient. To summarize the data set for a selection of OECD countries, and having in mind that our interest is to explore broad patterns of inequality evolution, we computed five-year averages for each country, with the exception of the Nordic countries. Five-year averages yield a more compact and succinct expression of the evolution of inequality, as Table 1 shows, by suppressing the gaps in the data. However, one must also be careful in noting that the averages were computed with different numbers of cases; often, only one value was considered, either in, or in the immediate neighborhood of each interval.

Table 1: Five-year averages of Gini coefficients for OECD countries, 1970-1990.

	Average Levels			
	Period 1	*Period 2*	*Period 3*	*Period 4*
	1970-1975	1975-1980	1980-1985	1985-1990
Australia	-	37.3	38.8	39.3
Belgium	-	28.3	26.2	26.4
Canada	31.6	31.5	32.0	30.7
Czech Rep	21.8	20.3	21.5	20.0
France	43.5	38.9	34.9	-
Germany	30.6	32.1	31.4	-
Greece	35.1	-	33.3	35.2
Italy	40.0	36.3	33.1	34.0
Japan	34.4	33.7	34.6	36.2
Korea, R.	34.7	38.9	36.3	34.1
Mexico	57.9	54.0	50.6	55.0
Netherlands	28.6	28.4	27.7	29.4
New Zealand	30.0	32.4	34.6	36.9
Portugal	40.6	36.8	36.8	36.2
Spain	37.1	26.8	26.0	25.5
UK	24.9	23.6	25.7	29.8
USA	34.3	34.9	36.4	37.7

Table 1 illustrates the significant changes in the patterns of inequality over the 1970s and 1980s. If we rank countries by level of inequality, we find that in the first period the most unequal countries were the Latin/Mediterranean Southern European countries. In fact, during the early half of the 1970s the most unequal countries, with the exception of Mexico, were, in descending order, France, Portugal, Italy, Spain, and Greece.

In the second period France remains the most unequal country, but Korea and Australia surpass Portugal and Italy. In Spain inequality falls substantially, and the US surpasses Japan in inequality. Throughout the two periods the UK is the most equal country, with the exception of communist Czechoslovakia, a position that the UK retains in the third period. Australia surpasses Portugal, and the US is the third most unequal country in the OECD, if we discount Mexico. Finally, in the last period, the US becomes the most unequal country, behind Australia. The effects of the increasing in inequality in the US and in the UK since the early 1980s are finally felt, and the UK loses its position as the least unequal country in the OECD. Some patterns emerge from the observation of Table 1. To make the identification of the patterns easier, Figure 2 separates the countries in three groups.

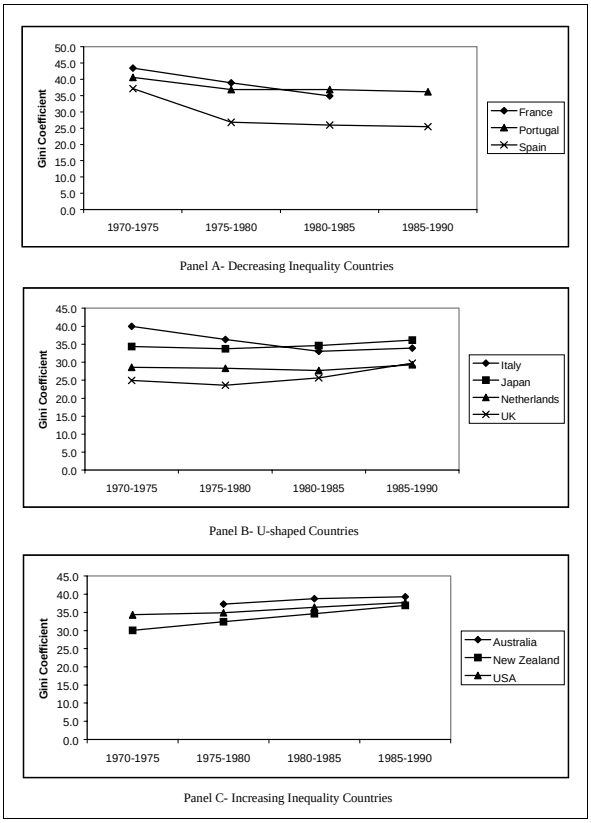

Figure 2: Patterns of inequality in OECD countries.

First, the countries that exhibited the highest levels in the first period (France, Portugal, Italy, Spain) became more equal throughout the period, with relative decreases in inequality ranging from 10% in Portugal to more than 30% in Spain. Panel A of Figure 2 depicts the evolution of the Gini for the countries that had a negative relative change throughout the period.

Italy, along with the UK, the Netherlands and Japan, is depicted in Panel B. These countries have in common a U-shaped evolution of inequality, with the inversion point (from decreasing to increasing inequality) differing from country to country. Japan and the UK were the first to switch in the 1975-1980 period, followed by Italy and the Netherlands in the next period. However, it is clear that the UK exhibits the strongest acceleration in the increase in inequality after switching occurs. Note that the relative change for the UK in the increasing periods are 8.7%, 15.8%, and 19.5%, compared with 2.7%, 4.5% and 5.2% for Japan. In fact, with the exception of New Zealand, the UK was the country in which inequality grew the most, by almost 5 points in the Gini.

New Zealand, along with Australia, and especially the US, exhibits a consistent pattern of increasing inequality throughout the period, as Panel C of Figure 2 shows. The increase in inequality in the US accelerates in the 1980s, but is looks like the upward trend has its origins in the 1970s. Throughout the period, the relative increase in inequality in the US is of 10%, second only to New Zealand and the UK.

Korea seems to show a distinctively different pattern, unlike any of the other OECD countries. Inequality in Korea witnesses a sharp increase from period 1 to period 2 of more than 12%, which is larger than the change suffered by the US in the entire 20 years. This increase in the 1970s was followed by substantial decreases in the remaining two periods. This observed decrease more than compensated for the sharp growth in inequality in the 1970s, suggesting an inverted-U evolution of inequality over time for Korea.

Czechoslovakia and Mexico show an oscillating pattern over time, but the institutional setting for these countries is very different from all the others. In Canada and Belgium, the tendency is towards a decrease in inequality, with only one small increase between periods for each country.

Since we are interested in characterizing the dynamics of evolution of inequality establishing connections with the macroeconomic context, the obvious place to start is the Kuznets hypothesis. How does the Kuznets hypothesis stand the test of confrontation with the Deininger and Squire data? Just plotting the countries for which there are more observations, the US, the UK, and Japan, we can see from Figure 3 that the evolution of inequality in these countries is not consistent with the Kuznets conjecture.

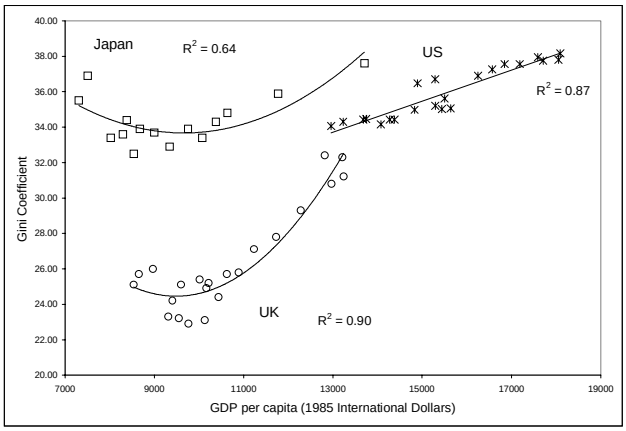

Figure 3: Patterns of inequality in the more advanced nations.

Figure 3 suggests that an augmented Kuznets curve whereby for high income countries inequality rises with income might be consistent with the recent experience across the dynamics of inequality in the OECD. The challenge is the test of this new Kuznets curve.

4. Explaining the Patterns: A New Look at the Relationship Between Technology and Inequality

The Deininger and Squire, due to gaps in and inconsistency of data, do not suffice. We propose the utilization of an inter-industry wage Theil index to measure inequality, allowing the construction of long and dense time-series of inequality for virtually every country. Our data set, just for the OECD countries, permits us to double the number of observations available and, more importantly, provides a continuous series over time for all countries included. Our measures of inequality, plotted against GDP per capita, are plotted in Figure 4.

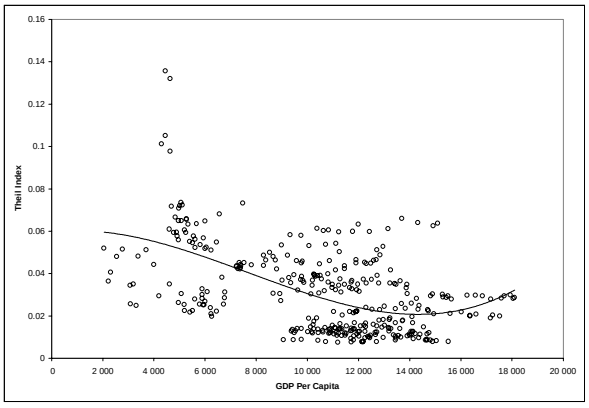

Figure 4: Inequality and Income for 19 OECD Countries (354 data points).

Figure 4 also shows the result of the interpolation of a function where inequality is a cubic polynomial of income. From this simple procedure, we see that our suggestion of augmenting the Kuznets curve is consistent with the data.

Thus, the fact that the patterns in movements of inequality in OECD countries are consistent with an augmented Kuznets curve suggests a further investigation on the mechanisms through which technology and inequality. Alternatives to the skill-biased technological change hypothesis need to be explored. As suggestions, it is important to investigate whether there is a systematic relationship between inequality with growth, along the lines pioneered Kuznets. Specifically, do countries reach a level of development after which inequality tends to increase with growth? In other words, after countries shift from an agricultural to an industrial society, following the inverted-U curve proposed by Kuznets, do they reach a certain threshold of development beyond which growth generates inequality? Secondly, does the degree to which a country's growth depends on new technology *generation* determine when the threshold was reached?

An hypothesis is that the countries that slide towards the upward segment of the augmented Kuznets curve are technological leaders, and the more preeminent the leadership, the faster, or the sooner, a country moves to the part of the curve where inequality increases with growth. However, this apparently simple hypothesis needs further elaboration. We will show how the mechanism through which growth leads to inequality is associated with the generation of technological change.

According to Schumpeter, only awarding monopoly power to the successful innovator permits technological change. Monopoly power is required to guarantee that the innovator appropriates a substantial portion of the benefits that result from the commercialization of the innovation. Monopoly power is required because, in the terminology of recent scholarship, innovations are non-rival or perfectly expansible. This concept translates the idea that innovations can be used simultaneously by as many as care to do so. The innovator has to be able to benefit from mechanisms (both formal, such as patents, and informal, such as secrecy) that make the usage of the innovation excludable. When other firms enter this race to introduce new innovations, we face the process of Schumpeterian competition.

Not all firms, nor all industries, act in the realm of Schumpeterian competition. In fact, for each country two separate clusters of industrial sectors will be identified. One including the industries that Galbraith [6] classifies as the K-sector (knowledge intensive, typically capital goods producer, where Schumpeterian competition is dominant), with the remaining industries being part of the C-sector (typically industries producing consumer products).

Why only two groups? A robust result of industry-level studies is that there is typically one dimension along which industries vary. Dickens and Katz [18], in a review of related literature, write: "Several authors have factor analyzed industry data and have found […] at one end of the spectrum industries which pay high wages, have substantial market power, tend to be made up of large firms with large establishments, have a higher union density, [and] have high capital-to-labor ratios. At the other end of the spectrum are those with the opposite characteristics." Galbraith [6] applies a clustering method to aggregate industries according to the similarity in wage changes over time, and finds the two groups, K-sector and C-sector, and, since in Galbraith study services are included, a third S-sector.

Thus, we will have for each country a K-sector that gains market power and has typically higher wages relative to the C-sector. Schumpeterian competition is dominant and monopoly power an important feature of firms in the K-sector. The implications for the distribution of income of a division between a K-sector and a C-sector are explored in Galbraith [6], but the intuition is simple. In the K-sector there are monopoly rents to distribute, and in the C-sector, since competition is assumed to be perfect and prices are equal to marginal cost, there are no rents. Galbraith argues that even if some of the rents are paid to owners of capital (typically accounted as labor compensation, anyway, Galbraith notes) a large proportion must flow to all workers in the form of efficiency wages.

Now we must establish the link of this model with the level of development of the country and with inequality. The idea is that in the leading developed countries growth is fueled by the expansion of the frontier of knowledge in the K-sector. As Keely and Quah [19] argue, these countries do not have the option of growing by importing machines or industrializing further, because they are already at the forefront of development. This means that the K-sector must be strong, and getting stronger the more vigorous the growth is.

The other countries can "learn", in the Pasinetti [20] sense, from the technologies generated in the leading countries. Diffusion, rather than innovation, fuels growth. The introduction of new technology is less dependent on monopoly incentives, and the K-sector is not as "different" from the C-sector. Thus, in this second group of countries, growth is compatible with decreasing or stagnant inequality.

It is important to stress, finally, that this explanation is an hypothesis, consistent with an augmented Kuznets curve, linking the dependency of growth on technological innovation with the positioning of countries in the Kuznets curve. Thus, it provides a new understanding of the relationship between technology and inequality which is consistent with the empirical evidence from OECD countries over the last couple of decades.

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