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INCOME INEQUALITY AND INNOVATIVENESS: AN APPLICATION FOR EUROPEAN COUNTRIES

Halil Tunalı*
Fatih Şahan**

Abstract

The major aim of this paper is to elaborate the relationship between technological change and income distribution for 18 developed EU countries. A panel data model is estimated for the data covering the period between 1999-2014. The results suggest that, technological progress occurred in EU countries works to the detriment of people who hold the top income shares. Moreover, the institutional variable is found to increase income inequality. The results underline some important lessons for developing countries.

Key Words: *Technological Change, Income Distribution, Panel Data Model*

JEL Codes: *D39,D63,O32*

1. Introduction

It was first highlighted by Schumpeter (1939) that innovations are the major drivers of economic growth. Real Business Cycle theories pioneered the central role of innovations for an economy to grow. With the accompanying progress in technology, economies have been growing faster throughout the recent decades. Faster growth came up with various problems, one of which is the rising income inequality both across and within countries. Various researchers argue that increasing innovative capacities of the countries is the major element contributing to unequal distribution.

The mechanism by which technological capacity[1] contributes to the rising inequality works as follows; when a new innovation occurs, the agents gain monopoly power in that area through patent protection and thus higher profits, the main motivators of innovations (Toivannen and Vaanaen,2012). According to a recent study based on Forbes, 11 of 50

1 Innovativeness and technological capacity is adopted as synonyms throughout this study.

* Doç. Dr., İ.Ü. İktisat Fakültesi Öğretim Üyesi, htunali@istanbul.edu.tr
** İ.Ü. İkitsat Fakültesi Doktora Öğrencisi, fatihsahann@gmail.com

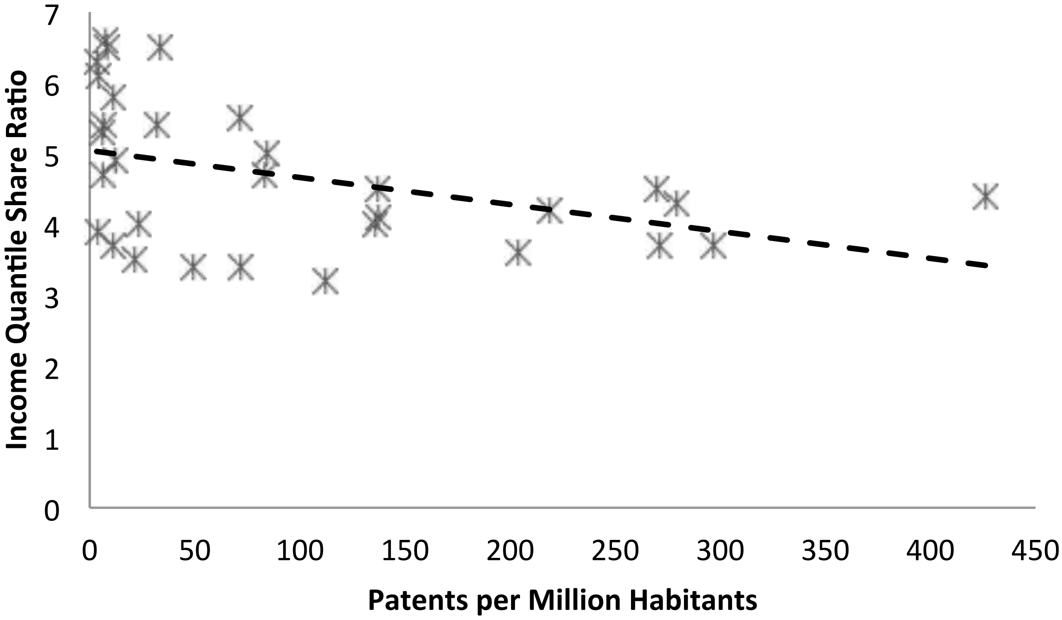
the richest people in the United States signed with a patent (Aghion,et.al., 2015). The workers of the innovative sectors, furthermore, have higher wages than the normal level creating another contribution to the inequality. The employees of such kind of sectors are from high skilled labor, indicating that returns to skill soared in the recent years with the ongoing technological progress (Acemoglu, 2002). Therefore, incrementing inequality is of vital importance for the policy agendas of the countries who aims to improve innovativeness.

The existing literature concentrates mainly on functional income distribution and wage inequality in this subject (IMF,2007;European Comission,2007). In these works, the main focus is put on the returns to skill and wage inequalities. Acemoglu(2002) indicates the skill distribution within countries determines the direction of technological change. He develops an explanation for the rising inequality based on the institutions in addition to the traditional approaches. Aghion, et.al. (2015) and Stockhammer (2009) incorporates innovativeness as the major and a significant determinant of inequality.

The US and EU experienced highly increasing technological progress in the recent decades. However, inequality in the EU has not been increased relative to the US (Acemoglu,2002). Therefore, EU countries are selected for application in this study. Figure-1 illustrates the share of income quintile share ratio[2] and patents granted for the year 2012. This picture clearly suggests that income quantile share ratio is negatively related to the patents granted in EU countries. This point constitutes the starting point of the empirical study employed in this paper. What drives this relation in the EU countries? Is the rising inequality an inevitable outcome of technological progress? These questions are mainly evaluated through this study.

2 This ratio of the income share held by the richest quintile to income share held by the poorest quintile.

Figure-1: The Basic Relation between Innovation and Income Distribution



Source: Eurostat, European Patent Organization (EPO)

The remainder of the paper proceeds as follows; Section 2 elaborates main strands in the literature. Section 3 presents data and methodology applied as well as section 4 showing the results of the estimation. The last section summarizes and concludes.

2. Literature Review

There are two major strands in the relevant literature. First strand analyzes income inequalities from growth perspective. Since the innovations are the main engines of growth, one can set the linkage between inequality and innovation through economic growth. Forbes (2000) finds a positive relation of innovation induced growth with inequalities by employing a panel estimation technique for some of the OECD countries.

The second and more relevant strand of literature concentrates on the skill biased technical change. Acemoglu(1998) shows that expansion of skills in the US Economy can be responsible for the rise of inequality in 1980s. To clarify, he argues that when more high skilled workers are integrated to the economy, skill premium may decline, but in the medium run skill biased technology arises and this may result in wage inequalities. Caselli (2000) argues that this kind of technical change may lead to the complementarity of low skilled labor with the technological equipment. Hermous and Olsen (2014) finds that when a horizontal innovation (e.g. a new product) occurs, it may replace the low skill labor, but with the time, low skill labor wages grows at a lower rate than the high skilled labor through a growth model. Most of these studies focus on the wage inequalities and skill level. This paper mainly focuses on the innovations themselves, rather than the skill induced innovativeness.

Specifically, empirical literature concerning the determinants of inequality through technological capacity mainly concentrates on the three channels. First, greater integration of the markets to the rest of the world may explain income inequalities. Richardson(1995) indicates that trade affects income inequalities both in the short run and long run, former being stronger. IMF (2007) suggests that it is technological change that contributes to the rising income inequalities and globalization has a secondary importance. On the other hand, Stockhammer (2009) replicated the results of IMF and concluded that global integration is as important as technological change in explaining inequalities. Adams (2008) provides evidence for this view by employing seemingly unrelated regressions for a panel of 62 countries and for the period between 1985-1992. He finds that openness to trade is positively related to income inequality. Esquivel and Rodriguez-Lopez (2003) presents similar results for their application on Mexico for the period between 1988-2000. Besides, Gancia (2012) adds to this line by finding that offshoring and trade integration can stimulate the demand for skilled labor.

Second, though it is related to globalization, factor mobility can affect income inequality. From a theoretical point of view, free move of labor and capital may lead to the learning of low skilled labor. On the other hand, the empirical evidence of this point in the literature does not point a sound conclusion (Wood,1997). Third, the skill level of labor can be used to explain the income disparities across the countries. Jaumotte, et.al. (2008) argue that financial openness (through FDI) may diversify the opportunities for the high skilled labor and thus may hamper unequal distribution of income.

Table-1: A Brief summary of Literature

Name	Methodology	Dependent Variable	Independent Variables
Aghion et.al. (2015)	Panel IV	Income Share of Top 1 % population	Patents, Citations, GDP per capita, Population growth
Stockhammer (2009)	Panel FE	Wage Shares in Total Income	Growth of GDP,Patents, Balance of payments, financial globalization,capital accumulation,wage pacts
European Comission (2007)	Panel FE	Wage Shares in Total Income	Capital/Labor Ratio, ICT Use,Country Openness, Union Density,Union Benefit,Labor Tax Wage, Minimum Wage,Ouput Gap, Indirect Tax Rates, Product Market Regulation, EPL,skill levels, Labor market institutions
IMF (2007)	Panel FE	Labor Share in Total Income	Relative Export and Import Prices,Labor/Capital Ratio,Offshoring, Immigration,ICT Capital, Taxes,Unemployment Benefits.
Ellis and Smith (2007)	Panel FE	Wage Shares in Total Income	Growth of GDP,Product Market Regulation,oil price, real exchange rate.
Toivannen and Vaanaen (2012)	Panel FE	Annual Wage Income	Number of patents, citation weighted patents,Age, female dummy,firm size, level of education
Jaumotte et.al (2008)	Panel FE	Gini Coefficient	Export/GDP Ratio,Ratio of Inward FDI Stock,Ratio of inward portfolio equity stock to GDP,Ratio of inward debt stock to GDP,Ratio of outward FDI stock to GDP,Capital account openness index Share of ICT in total capital stock,Credit to private sector (percent of GDP)
Weinhold and Nair-Reichert (2009)	Panel FE	Patents	Patents, patent protection index, Institutional quality index (Kaufman et al), Average years of schooling index, openness index

Adams (2008)	Seemingly Unrelated Regressions	Gini Coefficient	Trade share of GDP,globalization, openness, FDI Intellectual property rights (Ginarte–Park index of patent rights)
Jayadev (2007)	Panel FE	Compensation of employees/ GDP	GDP per capita, capital account openness, trade openess, trade taxes,real interest rate,crisis, government share of GDP,Budget deficit
Roine et.al. (2009)	FD-GLS	Income share of percintiles	Patents, Agricultural share of GDP, GDP per capita, Population growth, government spending, capitalization of banking sector, openness, marginal tax rate
Antonelli and Gehringer (2013)	Panel FE	Gini Coefficient	Patent, openness, GDP per capita,Investment, Government Spending, Total Factor Productivity Growth
Forbes (2000)	Panel FE	Growth	Female Education (secondary school environment),GNP per capita, Gini coefficient, Male education (secondary school environment), price level of investment

Third, the institutions such as enforcement of intellectual property rights and patents have a crucial role. In its simplest way, intellectual property is the main motivation for the innovations, as the inventors aim at monopoly profits (Toivannen and Vaanaen,2012). Besides, from a more general point of view, other factors that determine “the rules of game” in the economies, ranging from free democracy to welfare states, may be effective on the inequality trends (Palme,2006). Therefore, institutional structures of the countries play a significant role in their inequality trends.

3. Data and Methodology

In this paper, it is proposed to examine whether the innovations occurring across countries can explain the income inequality in its broader sense. The indicators adopted are selected from literature review. In order to handle the inequality, income shares of the richest people is selected following Aghion et.al.(2015). For the innovativeness of a country, patents granted is selected as a proxy, which is a widely used innovation indicator in the literature (e.g. Toivanen and Vaanen,2012). The rationale behind the use of income shares and patents per habitant statistics is that patents are indicators of innovations and innovators are enjoying high profits as a consequence of their innovations.

As control variables, skill upgrading, population growth, development level are employed (Table-1). For skill upgrading, tertiary enrollments and to indicate development level, real GDP per capita is adopted (Antonelli and Gehringer (2013); Forbes (2000)). The institutional quality is also added to the model, which is used to explain inequality patterns in the studies such as Acemoglu et.al. (2001) and Weinhold and Nair-Reichert (2009). The index of Polity IV dataset of Systemic Peace is a good and widely used proxy for institutional quality. In setting up this dataset, they simply analyze authority characteristics of the countries and set indices based on the data aiming at usage of them in the quantitative research (Systemic Peace, 2013:1). Also, openness, measured as the share of total trade in GDP, is included in the estimation following Adams (2008) (Table-2).

The econometric analysis is applied to European Union countries, since they are technologically advanced and have more even income distributions in comparison to the other regions of the World. The countries are selected from the UN-Human Development Index's "Very High Human Development" category[3] since it is claimed that the more a country's social institutions work in favor of equality, the less inequality the innovations create[4].

Table-2: Data Sources Used in the Estimations

Subject	Indicator	Data Source
Income Equality	Income Share held by the richest quintile (PPP Standard)	Eurostat
Innovation	Patents per 1 Million Habitants	Eurostat

3 This report is published by UNDP per annum and provides statistics for various development indicators ranging from energy use to demographic indicators. In this study, the most recent report that is published in the year 2013 is used.

4 The selected countries and summary statistics are depicted in the Appendix, Table A.1.

Skill Upgrading	Tertiary School Enrollments in Total Enrollments	World Bank ,World Development Indicators
Institutional Quality	Polity Index	Polity IV Project, Systemic Peace
Integration	Total Trade Share in GDP	World Bank, World Development Indicators
Development Level	Real GDP per Capita	Eurostat
Population Growth	Population Growth	Eurostat

Since the dataset is in panel format for 18 countries with 16 years, one can apply commonly used panel data estimation techniques. Based on the data, the model to be estimated is as follows;

$$INEQ_{it} = \delta TECH_{it} + x'_{it}\beta + u_{it} \text{ where } \mu_i + \vartheta_{it} \quad (1)$$

where is inequality measure, innovations, is the set of control variables and and , is a matrix of exogenous regressors and is matrix of coefficients and is a scalar. In the model, are fixed parameters and assumed to absorb unobserved effects that are differing across countries. These models are appropriate in case of N firms or in analyzing N European Union countries (Baltagi,2008:14), since they capture differences through time, not countries. This is one of the most common panel data estimation methods called Fixed Effect (FE) estimation. When one allows to change across specific entities, (in our case countries) then, random effects model would be the more appropriate.[5]

The first step in our case is to determine the estimation technique. Commonly applied test in the related literature is Hausman test based on the test of correlation between and regressors (Greene,2010: 416-421). Although this test is criticized in the sense that it does not provide sufficient evidence on the decision of FE or RE model usage (e.g. Clark and Linzer,2015), it provides a rationale on the issue. The null hypothesis of the test is the model to be estimated is random effects model.

As a second step, coefficients are estimated and diagnostic tests are executed to evaluate model performance. One important point in these

5 For a detailed account of random and fixed effect models, see Baltagi (2008:13-55)

models is to test the independence of cross sections, as cross sectional dependence may create bias in the test results (Hoechle,2007). Therefore, the test developed by Pesaran(2004) is employed. The null hypothesis of this test is that residuals do not differ across cross sectional units. To test for heteroskedasticity, Modified Wald Test, having the null of homoscedasticity, is used in this work (Greene, 2010: 338-339). The model is also checked for robustness to different specification. In this sense, the model is to be estimated with different specification on the basis of goodness of fit and information criteria. Table-3 presents summary statistics of the data used in the estimations.

Table-3: Overview of Data

Variable	Observation	Mean	Std.Dev.	Min	Max
Top Income Share	201	37.6	2.6	32.8	45.7
Patent	252	147.6	109.9	3.7	434.2
Real GDP per Capita	252	40161.3	14882.3	17820.1	86129.4
Tertiary School Enrollments	231	61.1	18	9.8	116.6
Openness	252	98.6	59.9	44.7	352.9
Population Growth	252	0.007	0.006	-0.003	0.031

4. Empirical Findings

Empirical findings of this study are presented in three steps. In the first step, Hausman test is applied and found that FE model is more appropriate model for the subject in question with strong rejection of the null (Test Statistic: 75.49). Therefore, FE model is estimated.

Table-4: Fixed Effect Estimation Results[6]

Dependent Variable: Income Share	(1)	(2)	(3)	(4)	(5)	(6)
Patent	-0.0105*	-0.0101*	-0.0116**	-0.0094**	-0.0109**	-0.0092**
	(1.89)	(1.89)	(2.31)	(2.3)	(2.29)	(2.42)
Real GDP Per Capita	0.0342	0.033	0.0235	0.0098	0.0204	
	(0.96)	(0.92)	(0.95)	(0.59)	(0.81)	

6 In the estimations, data are transformed via taking natural logarithms.

Regime	0.0872***	0.0895***	0.0926***	0.0996***	0.0892***	0.0954***
	(5.6)	(5.64)	(6.48)	(8.02)	(5.94)	(7.64)
Tax	0.0288	0.0271	0.0341	0.0287		
	(1.26)	(1.16)	(1.46)	(1.39)		
Population Growth	-0.4681	-0.4116	-0.4457		-0.3662	
	(1.02)	(0.89)	(1.02)		(0.82)	
Tertiary Education	-0.0052	-0.005				
	(0.45)	(0.45)				
Openness	-0.0111					
	(0.57)					
N	*183*	*183*	*201*	*201*	*201*	*201*
Number of Countries	*17*	*17*	*18*	*18*	*18*	*18*
R^2	*0.21*	*0.21*	*0.23*	*0.21*	*0.21*	*0.20*
Cross Sectional Dependence	*-2.050*	*-2.096*	*-2.219*	*-2.118*	*-2.190*	*-2.088*
	[0.451]	*[0.462]*	*[0.462]*	*[0.422]*	*[0.423]*	*[0.412]*
Year Dummies	*18.48*	*17.63*	*23.41*	*22.62*	*26.82*	*16.88*
	[0.000]	*[0.000]*	*[0.000]*	*[0.000]*	*[0.000]*	*[0.000]*
Heteroskedasticity	*3592.77*	*4521.93*	*906.47*	*999.35*	*1091.75*	*981.73*
	[0.000]	*[0.000]*	*[0.000]*	*[0.000]*	*[0.000]*	*[0.000]*

** significant at 10%; ** significant at 5%; *** significant at 1%; year dummies are included in al regressions, but not reported and available upon request; heteroskedasticity consistent standard errors; robust t statistics in (), p-values in [ ];Null hypothesis of cross sectional dependence is no cross sectional dependence; F statistics are reported for the joint significance of year dummies; Null hypothesis of heteroskedasticity test is no heteroskedasticity.*

As a second step, estimation results are presented in Table-4. From the table, Model (3) is selected as the preferred model As regards to the main point of this paper; the patents have significant effect on the income share held by the richest people. The effect of innovations on the inequality is negative in these countries, which is parallel to Acemoglu (2002), meaning that the innovations occurring in the developed European countries are not in favor of income shares held by the richest people. This finding can be attributed to the institutional structure of Europe, which is against the income inequality.[7]

As regards to the regime variable, it has positive and strongly significant effect on the top income shares. This variable evaluates the democracy and freedom levels of countries. Taking this fact into account, the developed European countries have political setting that contributes to the level of inequality.

As the third step, the estimation results are evaluated. First, estimation outputs are checked for various combinations, 6 of which are presented in Table-4 and concluded that the estimation results are robust to different specifications. Second, the heteroskedasticity is determined by the relevant tests and heteroskedasticity adjusted standard errors are used. Third, all the time dummies included in the model are found to be significant and fourth, cross sections are independent.

One important problem, here, should be addressed, which is endogeneity. To the best knowledge of the author, there is no standardized endogeneity test in fixed effect models except Hausman specification test. The test results are in favor of strict exogeneity. This point is also reasonable in the sense that there is not a mutual causation between income shares and patents per habitants simultaneously. Therefore, model assumptions are met.

5. Concluding Remarks

In this paper, the relation between inequality and innovations are elaborated for the developed European countries. The relevant literature indicates that the relation between these two concepts relies on the countries and their development levels. In the US, for instance, this relation is found to be positive, while in China, it differs among regions. Therefore, for the EU countries, this relationship is found as negative. The major contribution of this paper is twofold. First, it incorporates institutional view quantitatively to the studies conducted in this issue and second, it puts strong emphasis on development indicators.

The results of this study highlight the importance of institutional factors

7 The relation is further investigated to address the presence of U-shaped relation between technology and inequality with the help of square of patent variable and found to be insignificant meaning that in the analysis period there is no standard U shaped relation in the EU countries.

in handling the inequality problem. The human development level observed in the developed European countries can be a role model for the developing countries. All the countries should develop institutions that focus not only on the technological progress, but also other types of development issues, namely energy use, social state. Under these circumstances, the technological progress may decline the income inequality. Furthermore, another lesson from this study is that, there is not a unique way of solving the increasing inequality problem.

For future research, the indicators can be diversified. Especially, in addition to the traditional explanations, institutional indicators should be more on focus. Moreover, rather than country level studies, the question might be handled with the help of more detailed panels, namely sectoral data. Despite these shortcomings, this study helps to understand the fact that the gains emanating from technological progress can be distributed to different income classes with the help of institutions in favor of different aspects of development.

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Appendix

Table A.1: Countries and Average Statistics

Country	Top Income Share	Patent	RGDP (constant, USD)
Luxembourg	37	176	78374
Norway	35	98	65291
Switzerland	39	406	55474
Denmark	34	214	47834
Ireland	39	68	47620
Sweden	34	272	42470
Netherlands	36	212	41892
United Kingdom	40	92	38716
Austria	36	185	38596
Finland	35	259	38353
Belgium	36	136	36590
Germany	37	278	35683
France	38	130	34674
Italy	39	76	31376
Spain	40	28	25873
Cyprus	38	12	24065
Greece	41	7	21269
Portugal	44	8	18753

Table A.2: Correlation Matrix

	Income Share	Patent	RGDP	Tertiary	Openness	Population Growth	Tax	Regime
Income Share	1							
Patent	-0.619	1						
RGDP	-0.495	0.4733	1					
Tertiary	-0.1557	0.0454	-0.1951	1				
Openness	-0.2126	0.147	0.6536	-0.5298	1			
Population Growth	-0.0162	-0.2209	0.3084	-0.4	0.4662	1		
Tax	-0.3002	-0.0845	-0.1068	0.2029	-0.1003	-0.1036	1	
Regime	0.104	0.0346	0.0739	0.0147	-0.0062	-0.0246	-0.0629	1