IMPACT OF INTELLECTUAL PROPERTY RIGHTS AND GOVERNMENTAL POLICY ON INCOME INEQUALITY.

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─Abstract ─

The hypothesis of inverted U-curve dependence of the income inequality on the absolute value of the average income is still unresolved issue despite of the growing number of theoretical and empirical research on this topic. The paper examines the impact of governmental policy and the scientific and technological development on income inequality for 145 countries over a period 1979-2012. We found that the income inequality is influenced predominantly by governmental policy on social transfers. Based on the experimental data a model describing the influence of social contributions, the expenditure on research and development, intellectual property rights and GDP per capita was developed.

Key Words: *Intellectual property rights, Kuznets curve, inverted U-curve, income inequality*
JEL Classification: O15, O34, O38

1. INTRODUCTION

Simon Smith Kuznets (1955) suggested existence of a general relationship between the income inequality and the income per capita. His hypothesis states that the income inequality initially rises with economic development but after reaching its maximum it subsequently falls in advanced stages of economic development. Hence, the relationship between the income inequality and the income expressed as GDP per capita has shape of inverted U-curve. The Kuznets inverted U-curve hypothesis can be undoubtedly considered as one of the most influential statements ever made on inequality and development. Although many theoretical models can predict the Kuznets U-curve, empirical evidence for the validity of the Kuznets hypothesis is still a matter of controversy. Empirical research on the validity of the Kuznets hypothesis was performed by many authors during last 40 years, but obtained results are controversial and not conclusive. Ahluwalia (1976) in his early work found support for the Kuznets hypothesis, but Anand and Kanbur (1993) re-analyzed later the same data and did not find any evidence supporting the Kuznets hypothesis. Similarly Deininger and Squire (1998) did not find any support for the Kuznets U-curve either in the cross-country analysis or in the country specific inter-temporal data. In contrast to this, Jha (1996) analyzed observations for 76 countries for the period 1960-92 and found that the Kuznets hypothesis holds. Similarly Bulir (2001) and Hayami (2005) reported that the Kuznets hypothesis is supported by empirical data. Parametric and semi-parametric testing of the Kuznets hypothesis performed by Lin et al. (2006) gave also support for the Kuznets hypothesis.
The income inequality is usually measured by the GINI coefficient while the GDP per capita characterizes the level of economic development. Most studies followed the approach of Ahluwalia (1976) and performed linear regression of GINI index on the logarithm of GDP per capita and its square term, i.e. the relationship between GINI index and GDP per capita is assumed in the form

$$\mathrm{GINI}_i = \beta_0 + \beta_1 \log(\mathrm{GDP})_i + \beta_2 \log(\mathrm{GDP})_i^2 + \varepsilon_i . \qquad (1)$$

Positive coefficient β_1 and negative β_2 obtained from regression are viewed as a support of the validness of Kuznets hypothesis. The maximum of the inverted U-curve described by Eq. (1) occurs at GDP per capita

$$GDP_{TP} = 10^{-\frac{\beta_1}{2\beta_2}}, \qquad (2)$$

which represents the 'turning point', i.e. the level of development from which inequality should decrease with further economical development. The maximum value of GINI coefficient predicted by the Kuznets U-curve is

$$GINI_{max} = -\frac{\beta_1^2}{4\beta_2} + \beta_0. \qquad (3)$$

The quantities GDP_{TP} and $GINI_{max}$ calculated from results of analysis performed previously by various authors and listed in Table 1 exhibit a big scatter which hinders any meaningful prediction of the turning point position. Since in the Kuznets hypothesis GDP_{TP} and $GINI_{max}$ are principal quantities describing a fundamental economical law, the failure of various analyses to agree at these quantities arises some doubts about the validity of the Kuznets hypothesis.

Table 1: Summarized Results of Data Analysis Testing Validity of the Kuznets Hypothesis

period	number of countries	number of pairs	fraction of complete data (%)	$GINI_{max}$ (%)	GDP_{TP} (constant 2005 USD)	reference
1965-1971	60	60	0.6	57.6	692	Ahluwalia (1976)
1970-1990	75	75	0.8	62.7	2394	Bulir (2001)
1990-2000	44	45	0.5	45.0	2775	Hayami (2005)
1965-2003	82	82	0.8	46.0	2770	Iradian (2005)
1970-1990	75	75	0.8	45.9	982	Lin et al. (2006)
1979-2012	145	855	8.6	44.1	2033	This work

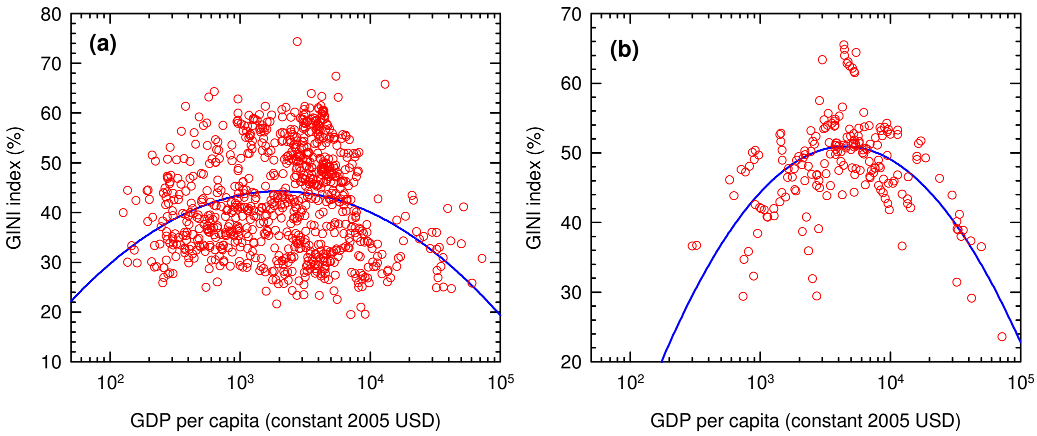
The empirical analyses of Kuznets hypothesis suffer from small number of data available. Considering that the income inequality is being traced from 1960 and taking into account the number of countries in the World, a complete data set would contain around 10000 pairs of GINI index and GDP per capita measured annually. Unfortunately only a small fraction of these data is available mainly due to lack of the GINI index values. Table 1 summarizes the time period, the number of countries involved in analysis as well as the number of GINI index - GDP per capita pairs used in the previous studies. The number of GINI index - GDP per capita pairs analyzed so far represents less than 1% of the complete data set.

In this work we performed a detailed analysis of the relationship between the income inequality and the level of economic development on a large sample representing 8.6% of the complete dataset. In our analysis we considered also the influence of governmental active policy do decrease inequality and the impact of research and technological development and intellectual property rights (IPR).

Table 2: Basic Statistical Description of data

	samples	mean	median	St dev	min	max
GINI	855	42.0	41.4	10.3	19.4	74.3
log GDP per capita	8037	3.44	3.99	0.701	1.7	5.2
social contributions (% GDP)	1297	6.02	4.46	5.41	0	20.5
resident patent applications	3725	7328	213	3.5×10^4	0	4.2×10^5
non-resident patent applications	4115	4420	379	1.4×10^4	0	2.6×10^5
research and development expenditure (% GDP)	1137	0.965	0.595	0.954	6×10^{-3}	4.84

Figure-1: Dependence of the GINI Index on the Common Logarithm of GDP per Capita

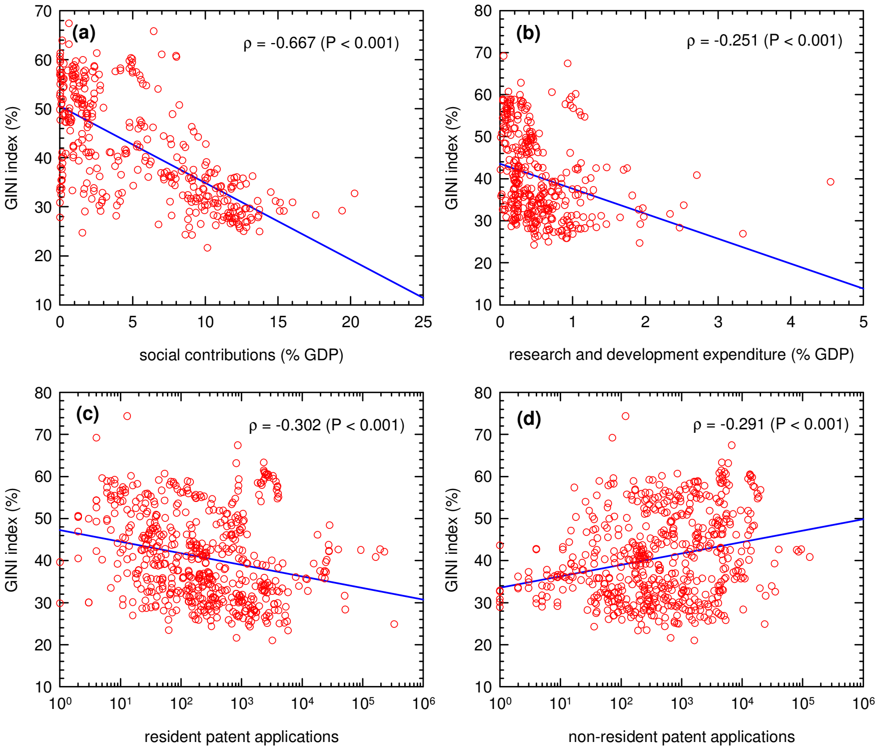


Note: All historical observations in the period 1979-2012 are plotted in the panel (a) while the panel (b) shows the GINI Index with subtracted social contributions and influence of IPR and research and development expenditure. Blue solid lines show result of linear regression using the U-shape curve described by Eq. (1). Source: WDI (2013), authors' calculations.

2. RESULTS

Analyzed sample consists of data available in the online World Bank database World Development Indicators (WDI) (2013) for 145 countries for which GINI index was measured at least once in the period 1979-2012. Basic statistic description of all available observations is given in Table 2. There are 855 matching pairs of GINI index and GDP per capita for the same country and the same year. Hence, our sample represents 8.6 % of the complete data set, which is at least 10 times larger size compared to previous works. Fig. 1a shows all data as a scatter plot of GINI index versus the common logarithm of GDP per capita (expressed in constant 2005 USD) for the same country in the same year.

Figure-2: Dependence of the GINI Index on the Social Contributions, the Research and Development Expenditure and the Number of Patent Applications



Note: The plots were constructed from matching pairs of the GINI index and (a) the social contributions (%GDP), (b) the research and development expenditure (%GDP), (c) the number of resident patent applications, (d) the number of non-resident patent applications. The solid lines show linear regressions. The Pearson correlation coefficient ρ and corresponding P-value are shown in each panel. Source: WDI (2013), authors' calculations

From visual inspection of data in Fig. 1a it is rather difficult to recognize any regular pattern which would suggest the inverted U-curve. Results of linear regression of the data in Fig. 1a by the Kuznets U-curve are listed in Table 3. The parameters GDP_{TP} and $GINI_{max}$ calculated from the fitted parameters are listed in Table 1. From fitting we obtained a negative value of β_2 and a positive value of β_1 coefficient which is in accordance with the inverted U-curve hypothesis. All coefficients are statistically significant. However, the R^2-value of 0.078 is rather low testifying to a poor agreement of the inverted U-shape curve with the empirical observations. Thus, GDP per capita can explain only a small portion of the income inequality data. Similar conclusion has been drawn by Barro (2000).
Governments in majority of countries apply active policy with purpose to decrease the inequality of the income distribution of their citizens. Most frequently this is realized by social transfers of money from the rich members of society towards the poor citizens. Hence, one should expect that the GINI index is influenced by the volume of the governmental social transfers. Fig. 2a shows a scatter plot of the GINI index plotted against the social contributions (expressed in % GDP). One can see in the figure that there is indeed a decreasing trend of the income inequality with increasing fraction of social contributions and the Pearson correlation test revealed statistically significant negative correlation. The relation between the GINI index and the social contributions s_i can be well fitted by a linear dependence

$$\mathrm{GINI}_i = \beta_0 + \beta_1 s_i + \varepsilon_i \quad (4)$$

The coefficients β_0, β_1 obtained from linear regression are listed in Table 3. The linear coefficient β_1 is negative and highly statistically significant. The R^2 value of 0.505 obtained in fitting by Eq. (4) is much higher than that resulted from fitting by Eq. (1). This suggests that social contributions can explain a large portion of the income inequality.
Various social contributions in various countries make the data in Fig. 1a biased and cause large scatter of the data points. In Fig. 3 the dependence of the GINI index on the logarithm of GDP per capita is plotted separately for countries with various social contributions. The data for countries with low amount of social contributions exhibit the inverted U-curve predicted by the Kuznets hypothesis, see Fig. 3a. But with increasing amount of social contributions the U-curve

becomes wider and wider and is pushed down to the lower values of the GINI index. Finally it becomes completely flat for countries with very high social contributions (> 15%), see Fig. 3d, although only a few points are available because the number of such countries is quite low. Hence, our analysis suggests that long standing controversies regarding the existence or non-existence of the Kuznets inverted U-curve were likely caused by the fact that the U-curve was blurred due to various amount of social contributions which influence the income inequality much more than the level of economic development.

Table 3: Results of Linear Regressions of the GINI Index dependence on various Indicators

Quantity	Coefficient	standard error	P-value
$GINI_i = \beta_0+\beta_1 (\log GDP)_i + \beta_2 (\log GDP)_i^2+\varepsilon_I$ *(original Kuznets inverted U-curve, Eq. (1))*			
β_0	-50	11	< 0.001
β_1	56.9	6.8	< 0.001
β_2	-8.6	1.0	< 0.001
R^2 (R^2 adj)	0.078 (0.076)		
$GINI_i = \beta_0+\beta_1 s_i + \varepsilon_i$ *(linear regression to social contributions s_i)*			
β_0	50.29	0.78	< 0.001
β_1	-1.542	0.083	< 0.001
R^2 (R^2 adj)	0.49 (0.49)		
$GINI_i = \beta_0+\beta_1 r_i + \varepsilon_i$ *(linear regression to research and development expenditure r_i)*			
β_0	42.70	0.80	< 0.001
β_1	-5.30	0.87	< 0.001
R^2 (R^2 adj)	0.092 (0.089)		
$GINI_i = \beta_0+\beta_1 \log pr_i + \varepsilon_i$ *(linear regression to resident patent applications pr_i)*			
β_0	47.5	1.1	< 0.001
β_1	-2.86	0.44	< 0.001
R^2 (R^2 adj)	0.070 (0.069)		
$GINI_i = \beta_0+\beta_1 \log pnr_i + \varepsilon_i$ *(linear regression to non-resident patent applications pnr_i)*			
β_0	33.49	0.49	< 0.001
β_1	2.75	0.26	< 0.001
R^2 (R^2 adj)	0.16 (0.16)		

Note: Goodness-of-fit is characterized by the R^2 coefficient and the R^2 adjusted to the number of degrees of freedom (R^2 adj).

Since the original Kuznets hypothesis was intended for modeling of the changes induced by a widespread use of some new technology replacing the previous one it is interesting to examine solely the effect of the level of research and IPR on the income inequality. The WDI indicators research and development expenditure (expressed in % GDP) and the number of patent applications can be used as suitable measures of the level of research and IPR, respectively. Scatter plots of the GINI index versus these indicators are presented in Figs. 2b-d and results of linear regressions of these data are listed in Table 3. Note that in the case of patent applications one should distinguish the patent applications from residents of the country concerned (Fig. 2c), and the patent applications from applicants outside the relevant country (Fig 2d). From inspection of Fig. 2b it becomes clear that an increase of the research and technological development in a country decreases the income inequality. Increasing level of IPR in the country measured by the residential patent applications decreases the income inequality as well (Fig. 2c). Opposite behavior was observed for the non-resident patent applications in Fig. 2d. This can be well understood since the number of patent applications submitted by non-residents does not represent a measure of the technological development in the country but rather its dependence on the technologies from abroad.

Table 4: Results of Linear Regression of Empirical Data by Eq.(5)

Quantity	Description	Coefficient	St dev	P-value
β_0	Constant	-166	45	< 0.001
β_1	log GDP per capita	117	25	< 0.001
β_2	(log GDP)^2 per capita	-15.8	3.4	< 0.001
β_3	social contributions	19.7	5.1	< 0.001
β_4	log GDP × social contributions	-11.9	2.7	< 0.001
β_5	(log GDP)^2 × social contributions	1.65	0.35	< 0.001
β_6	log resident patent applications	-3.00	0.47	< 0.001
β_7	log non-resident patent applications	3.89	0.50	< 0.001
β_8	research & development expenditure	-2.12	0.81	< 0.001
R^2 (R^2 adj)		0.80(0.79)		

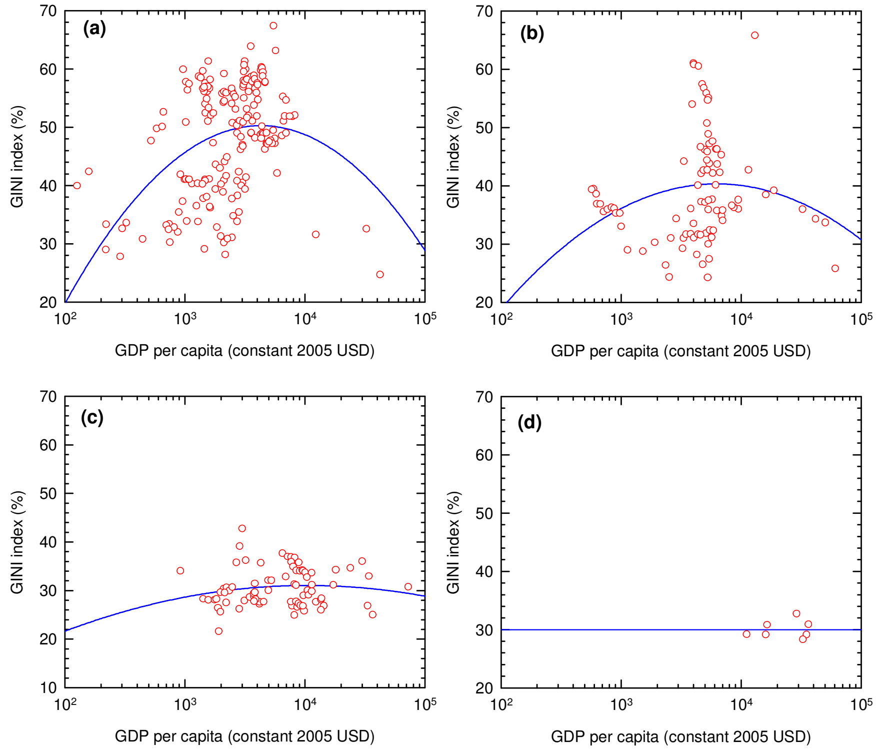
Note: The model function represents the Kuznets curve with maximum, width and turning point position modified by the amount of social contributions. In addition the number of patent applications by residents and non-residents and the research and development expenditure were taken into acount. The regression was made on 197 samples for which all indicators involved in Eq. (5) were available for the same year and country. Goodness-of-fit is characterized by the R^2 coefficient and the R^2 adjusted to the number of degrees of freedom (R^2 adj).

From the analysis presented here it follows that both social contributions, the level of research and technological development and also IPR influence the income inequality and should be therefore considered in statistical analysis of empirical data. The development of the income inequality can be expressed

$$\begin{aligned}\mathrm{GINI}_i &= \beta_0 + \beta_1 \log(\mathrm{GDP})_i + \beta_2 \log(\mathrm{GDP})_i^2 + \beta_3 s_i + \beta_4 \log(\mathrm{GDP})_i s_i \\ &+ \beta_5 \log(\mathrm{GDP})_i^2 s_i + \beta_6 \log(pr)_i + \beta_7 \log(pnr)_i + \beta_8 r_i + \varepsilon_i\end{aligned} \quad (5)$$

where *pr* and *pnr* denote the number of patent applications by residents and non-residents, respectively, and *r* stands for the research and development expenditure. Note that 5^{th} and 6^{th} terms in Eq. (5) are 'interaction' terms necessary to account for the broadening and the downward shift of the inverted U-curve with increasing social contributions. The results of regression by Eq. (5) are listed in Table 4. The coefficient β_1 is positive while β_2 is negative in agreement with the Kuznets hypothesis. The R^2 value of 0.80 testifies that the model described by Eq. (5) explains the major portion of the empirical data. To examine *solely* the influence of GDP per capita on the income inequality the effect of social contribution, level of research and IPR were subtracted from the original GINI index values. Fig. 1b shows such modified values of the GINI index calculated as $\mathrm{GINI}_i - \beta_3 s_i - \beta_4 \log(\mathrm{GDP})_i s_i - \beta_5 \log(\mathrm{GDP})^2{}_i s_i - \beta_6 \log(pr)_i - \beta_7 \log(pnr)_i - \beta_8 r_i$. Obviously after subtraction of the effect of social contributions, level of research and IPR the GINI index exhibits the inverted U-curve predicted by the Kuznets hypothesis.

Figure-3: Scatter Plots of the GINI Index versus the Logarithm of GDP per Capita for Countries with Various Amounts of Social Contributions



Note: The amount of social contributions is expressed in % GDP: (a) low amount (< 5 %), (b) intermediate amount (5-10 %), (c) high amount (10-15 %), (d) very high amount (> 15 %).The solid lines show fit by Kuznets curve given by Eq. (1). Source: WDI (2013), authors' calculations.

3. CONCLUSION

The Kuznets hypothesis was tested on data for 145 countries in the period 1979-2012. The income inequality is strongly influenced by the amount of social contributions which makes the panel data biased and blurs the Kuznets curve. With increasing amount of social contribution the inverted U-curve flattens and its maximum decreases. Moreover, the income inequality decreases with the scientific and technological development in the country.

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