

RESEARCH ARTICLE

# Innovations, Income Inequality, and Economic Growth Linkages: A Cross Country Analysis

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**Abstract:** Existence of intricacy of linkages amongst the innovation, income inequality and economic growth, have been considered in a thoughtful manner in this paper. The effects of the innovation on income inequality have been underscored in one way and the sways of innovation and income inequality together on economic growth on the other way. This research forms the panels of high, middle and low income countries. It is pertinent to mention that each panel holds 20 countries and time length ranges from 1996 to 2021. The Generalized Method of Moment (GMM) technique is used to obtain empirical evidence. The results reflect that innovation on economic growth turns out to be substantial indicator in economic growth in high income countries and causes reduction in income inequality, whereas innovation is least contributing factor in middle income countries and reflects insignificant impact on income inequality. On the other side, innovations are impactful in economic growth and have been imperious reducing the income inequality. Income inequality leaves adverse impact on economic growth in all the sampled countries. On the basis of findings, it is proposed to increase the investment on R&D which will not only further help opening the employment avenues but will also reduce the income inequality to experience the sustainable macroeconomic stability.

**Keywords:** Research and development, innovations, economic growth, income inequality

**JEL Classification Codes:** O1, O4

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## 1 Introduction

Innovations play a significant role in mitigating income inequality and in promoting economic growth. Economists focused on the issues of development and convergence of countries based on Solow's pertinent work (1956). Mankiw et al. (1992) later used the cross-country data to test the Solow growth model and concluded that human capital is an important determining growth factor. This conclusion was aligned with the empirical results of Solow's research. However, income differences are high between nations and regions (Benos & Tsiachtsiras, 2019). This difference in countries' relative income levels is due to the differences in their education level, infrastructure, research, administrative efficiency, and technology. The previous literature supported that innovations encourage economic growth and reduce income disparities among countries. The improvement in research and development subsidies and patent protection leads to higher economic growth rates. Consequently, due to economic expansion, the real interest rate increases, which increases the asset income and results in income inequality (Chu and Cozzi 2018). It is imperative to understand and comprehend the substantial role of innovations in mitigation of income inequality particular in developing countries (Bangoura et.al 2016; Milled et.al 2022). On the contrary, high incentives for research and development decrease the income disparity by declining the asset prices and profits. In the countries where the measure of quality is less than the threshold level, subsidies on R&D keep less bearing concerning to income inequality. Whereas, the patents' development has a positive and significant effect on the income disparity. The above findings are aligned with the results of Adams's research (2008). He used a patent right index constructed by Ginarte and Park (1997) to analyze the effect of improved patent protection on income differences. He found a positive and significant association between the patents' development and income inequality. Thus, those pro-growth policies seem to increase income disparity, but past research has shown that it is only applicable to the policy related to patents and not with R&D subsidies. The achievement of sustainable economic growth and development is a topic of concern for economists. In addition to suggesting growth factors, it is imperative to discover a new viable catalyst for economic growth. Some economists proposed that policies related to transparency, productivity, and competitiveness help sustainable development and growth. In contrast, others suggested the role of technology development and domestic innovation on sustainable economic growth. (Lawk, Sirmidi, and Goh 2020). This research aims to assess the influence of innovations in reducing income inequality and promoting sustainable economic growth for low, middle, and high-income countries. Firstly, the impact of innovations is analyzed on economic growth, and secondly, the effect of innovation is studied on the income inequality of different countries. Innovations play a significant role in increasing the economic growth of a country by increasing productivity. It helps in generating greater output with the same input. In short, the increase in productivity increases the number of goods and services produced in an economy. The core contribution of this attempt is to highlight the importance of the research and development in line with income inequality which further boosts the economic growth. It will definitely assist the developing nations to design a prudent policy making complemented with technical progress.

This paper aims to study the link amongst the innovations, income inequality, and economic growth for low, high, and middle-income countries. This research also attempts to measure the impact of innovations on income inequality.

## 2 Literature Review

A review of past studies is needed to get an insight into the ongoing issue and draw the concrete findings based on theoretical and empirical studies. Aiyar and Ebike, in the year 2020, conducted a study to examine the link between income inequality and development. The study found that lack of opportunities results in income disparity that negatively impacts the development of a country. Moreover, companies with an equal distribution of resources reduce income disparities among individuals.

Surya et.al (2021) inferred that a technological innovation really supports the economy to experience economic development sustenance and let the economy enjoy maximum benefits out of economic activities. They recommend the state that innovation in technology will enhance the productivity of community economic enterprises in Indonesia. Hémous and Olsen (2022) averred that long run tendency exists for a technical progress to displace the labor substitutability which additionally leads to reduction in income inequality and hence fostering the economic growth.

In 2018, Benos and Karagiannis conducted a study to investigate the link between income inequality and economic growth with a yearly panel of United States level data under the physical capital and human development. The study concluded that during the period from 1929-2013, the income disparity had not affected the economic growth in short as well as long span of time.

Benos and Tsiachtsiras (2019) conducted research and found the impact of Innovation on income disparity using annual panel data for 29 countries. They found that creativity reduces the gap in individuals' wealth by pairing the inventors and European Patent Office.

Bujari and Martinez (2016) studied the impact of technological innovation on economic progress. The study used the Data for twelve countries of South America from 1996-2008. The study found that technological innovations are positively interrelated with the economic growth of twelve selected countries of Latin America. The interesting insight was that investments in patents, high technology product development, and exports are imperative in increasing the overall factor productivity and per capita income of selected countries.

Chaudhry, Sabir and Gulzar (2019) conducted a study to find the impact of technology and financial development. The data were collected for the selected countries of South Asia from 1984-2017. The research used the GMM method to estimate the model. The study's findings found that technology, financial development, and human resources substantially affect selected countries' economic growth.

Chu and Wang (2019) researched the consequences of R&D's grants on a mixed growth model and proposes that may happen to be endogenous or foundational growth in the economy. The study analyzes the impact of two types of grants in enhancing productivity and creativity. The study found that R&D subsidies positively and significantly affect innovations only under the complete endogenous growth system.

In 2018, Farinha et.al inferred that the influence of entrepreneurship and innovation on economic growth. The research employed three methodologies to examine the effect of enterprise and innovations on productivity. The data on 148 countries were used to estimate the model. The study found that creativity plays a vital part in achieving competitiveness in the economies.

Włodarczyk (2017) conducted comparative research to examine the effect of innovation on income disparity. He ran regression by using the data of 30 countries on innovation

metrics and the Gini coefficient. The study found that the expenses on R&D to GDP ratio has a noticeable effect on income inequality. Chan et.al (2022) found that strengthening the patent right leaves positive influence on the income inequality whereas mounting research subsidies holds multifarious impacts on the income inequality, so do the economic growth.

It is evident from the above literature review that several attempts have been made to examine the income inequality on economic growth effects. In contrast, other studies are conducted to analyze the impact of innovation on economic growth. There are a very few studies which considered the income inequality and innovations together. The core idea of this attempt is to research the combined effect of innovation and income inequality on economic growth and inspect the impact of research and development on income inequality of different income levels of countries.

### 3 Methodology

This study considers two separate models; model one discusses the determinants of economic growth inclusive of research and development and income inequality, whereas Model 2 elaborates interconnection of R&D and income inequality.

This section explains the methodology used to estimate the impact of innovations and income equality on economic growth and also measure the effect of innovation on income inequality as well.

#### Model-1: Growth Rate Function

$$\begin{aligned} \ln GDP_{it} = \alpha_0 + \alpha_1 \ln(R\&D)_{it} + \alpha_2 \ln(PA)_{it} + \alpha_3 \ln(K)_{it} \\ + \alpha_4 \ln(GINI)_{it} + \alpha_5 \ln(PoP)_{it} + \mu_{it} \end{aligned} \quad (1)$$

$\alpha_0$  presents the intercept in this model 1,  $\alpha_1$  indicates the contribution of research and development,  $\alpha_2$  signifies share of patent rights,  $\alpha_3$  reflects the capital stock share,  $\alpha_4$  shows part of income inequality and  $\alpha_5$  is share of population in the economic growth. It is pertinent to explain here that all the variables have been taken in log and interpreted as elasticity of all the variables.

**Alternate Hypothesis:** Research and Development, patent rights, capital formation and income inequality effects the economic growth.

**Null Hypothesis:** Research and Development, patent rights, capital formation and income inequality does not effects the economic growth.

#### Model-2: Income Inequality Function

To estimate the association between innovation (R & D) and income inequality (GINI):

$$GINI_{it} = \gamma_0 + \gamma_1 R\&D_{it} + \epsilon_{it} \quad (2)$$

In model 2,  $\gamma_0$  is an intercept whereas  $\gamma_1$  connotes elasticity of the research and development (R&D) for income inequality.

**Alternate Hypothesis:** There is association between research and development and income inequality.

**Null Hypothesis:** There is no association between research and development and income inequality.

### 3.1 Panel Unit Root

To estimate the valid estimation, stationary is the foremost element. Since the nature of data in this research is panel, stationary of the data is checked through panel unit root tests of Liven, Lin, and Chu (Henceforward LLC) and Im, Pesaran, and Shin (Henceforth IPS). The outcome of these tests confirms that some of the indicators are stationary at level while some variables hold the characteristics of stationary at first difference.

### 3.2 Generalized Method of Moment (GMM)

To obtain the empirical evidence, the econometric technique Generalized Method of Moments (Henceforward GMM) is deployed. It is used for a cross-country analysis. This particular technique was introduced by Arellano and Bond in 1991. The lagged values of endogenous variables have been used as instruments for this study in both of the models instead of exogenous variables.

Therefore, the GMM technique is a better technique as it copes the issues regarding ergogeneity among the variables. So, for measuring the impact of innovations on economic growth and income inequality and its effect on income inequality and economic growth GMM will more appropriate technique to deal when it comes to deal with panel data (Risso and Carrera, 2019).

## 4 Results and Interpretation

This study explains the magnitude of associations among the policy variables of three different panels of countries. These panels are categorized as high income, middle income and low income countries as per the criteria determined by the IMF. Each panel consists of 20 countries and data ranges from 1996 to 2021.

### 4.1 Empirical Results of Panel Unit Root Test

The empirical findings of the panel unit root are portrayed in Table 1, for high-income countries. The results exhibit that the variables have different levels of integration. GDP, population, and R&D for example, are stationary at the first difference, whereas GCF, PA, and GINI are stationary at the level.

**Table 1: Panel Unit Root Outcomes of High-Income Countries**

Variable	Level		1st Difference		Outcomes
	CUR	IUR	CUR	IUR	
	LLC	IPS	LLC	IPS	
GDP	-2.81	-1.39	-11.79	-7	I(1)
	0	0.08	0.01	0	
R&D	-2.08	-1.89	-9.55	-9.09	I(1)
	0	0.01	0	0	
PA	-4.19	-3.22	-10.9	-8.98	I(0)
	0	0	0	0	
GCF	-2.82	-3.37	-10.97	-11.32	I(0)
	0	0	0	0	
GINI	-6.43	-2.69	-16.75	-6.82	I(0)
	0	0.03	0	0	
PoP	3.8	1.9	2.32	-2.77	I(1)
	0.99	0.97	0	0.03	
	0.58	0.54	0	0	

In the case of middle-income countries, the findings of LLC and IPS report the outcomes of GDP, PA, GCF, R&D, GINI and PoP stationary at first difference and since the p value is less than 5 percent. The results are mentioned in Table 2 below:

**Table 2: Panel Unit Root Outcomes of Middle-Income Countries**

Variable	Level		1ST Difference		Outcomes
	CUR	IUR	CUR	IUR	
	LLC	IPS	LLC	IPS	
GDP	-1.67	-0.1	-6.67	-3.88	I(1)
	0	0.41	0.01	0	
R&D	-2.82	-1.06	-12.5	-11.2	I(1)
	0	0.14	0	0	
PA	-0.86	0.22	-13.17	-8.87	I(1)
	0.16	0.58	0	0	
GCF	-1.56	-2.93	-10.39	-9.82	I(1)
	0.06	0	0	0	
GINI	-7.82	-2.89	-11.55	-4.88	I(0)
	0	0	0	0	
Pop	3.65	1.63	-2.37	-3.76	I(1)
	0.99	0.94	0.03	0	

The table 3 shows the panel unit root test for low-income countries. It indicates that GCF and R&D are reported to be stationary at first difference since the probability values of

these variables are less than 0.05 at level however PoP, GDP, PA, and GINI, are recorded stationary at level of low income countries.

**Table 3: Panel Unit Root Outcomes of Low-Income Countries**

Variable	Level		1ST Difference		Outcomes
	CUR	IUR	CUR	IUR	
	LLC	IPS	LLC	IPS	
GDP	-1.78	-2.59	-8.27	-7.52	I(0)
	0.03	0.01	0	0	
R&D	-2.69	-0.72	-36.2	-10.07	I(1)
	0	0.23	0	0	
PA	-3.68	-2.49	-12.01	-10.27	I(0)
	0	0	0	0	
GCF	-0.6	-1.5	-11.06	-8.98	I(1)
	0.26	0.06	0	0	
GINI	-9.11	-98.96	-11.84	-4.82	I(0)
	0	0	0	0	
Pop	-7.07	-2.57	-2.53	-3.53	I(0)
	0	0	0	0	

## 4.2 Hausman Test Results

For the whole panel of countries, the Hausman test results reveal the rejection of null hypothesis and that confirms the validity of alternative hypothesis, which implies that the fixed effect is more apposite comparing with the random effect model. P values in all three countries case is below the 0.05 level which is 0.03.

## 4.3 The Results of High-Income Countries of the Generalized Method of Moment- GMM

According to the findings depicted in Table 4, R&D have a considerable negative influence on GDP. The expenditures on research and development are very substantial, and high-income countries are top in research which is one of the burdens on the other hand. R&D had adverse impact which is -23 percent impact on GDP. The findings show that PA have a 20 percent impact on GDP and it is positive too. These findings are similar to Romer (1986) and Lucas (1988), who stated that PA holds favorable and considerable impact on the economic growth. The GCF has a considerable impact and contributes 22 percent in GDP. This result is compatible with Chu and Cozzi (2018). The result shows that the government can boost the economy's growth by increasing physical capital and spending on research and development or motivating people to innovate by securing their patent rights. As discussed earlier, that GINI is used as the proxy of unequal income distribution. The above

results show that GINI affects economic growth adversely but insignificantly. In high-income countries, there is less income disparity and Grundler & Scheuermeyer (2018) came up with the alike findings. Furthermore, the results reflect that population backs 55 percent in economic growth, which imply the diversity of labor force in developed countries.

**Table 4: Findings of Penal Generalized Method of Moments (High Income Countries – Model 1)**

S.No	Variable	Coefficient	Prob
1	R&D	-0.23	0.00*
2	PA	0.2	0.00*
3	GCF	0.02	0.01*
4	GINI	-0.1	0.29
5	PoP	0.55	0.00*
6	C	14.92	0.00*

Note: \* denotes the 5 percent level of significance.

Table 5 presents that innovation and R&D significantly impact economic growth. Finding implies that R&D pushes GDP by 40 percent in the middle-income countries. PA is also positively and sustainably connected with GDP. Its share in GDP is 10 percent and results have profound matching with the results of Romer (1986) & Lucas (1988). As for as GCF is concerned, it is positively connected with GDP and its share in GDP is reported to be 14 percent. The findings related to GCF are aligned with study of Chu and Cozzi, (2018). It further explains that government can boost the economy’s growth by increasing physical capital and spending on research and development or motivating people to innovate by securing their patent rights. Whereas, GINI is negatively interconnected with GDP in middle income nations. Its share is -20 percent, which means it serves as potential threat for the economy. Similar findings have been carried out by Grundler & Scheuermeyer (2018). In middle income countries pane, PoP leaves adverse influence on GDP which is 59 percent. It further reveals that unlike the developed nations, middle income nations have less productive labor.

**Table 5: Findings of Penal Generalized Method of Moments (Middle Income Countries – Model 1)**

S.No	Variable	Coefficient	Prob
1	R&D	0.04	0.00*
2	PA	0.1	0.05*
3	GCF	0.14	0.01*
4	GINI	-0.02	0.00*
5	PoP	0.5	0.00*
6	C	16.99	0

Note: \* denotes the 5 percent level of significance.

Table 6 portrays the results of low income countries. R&D influences the GDP by 28 percent and positively as well, whereas the role of PA in GDP is positive as well as significant. Its share in GDP is recorded 21 percent. Concerning to the GCF influence in GDP, is 10 percent



and also has profound impact while GINI is insignificantly connected with GDP by value of -10 percent. The scenario of PoP is very much similar to the middle income countries, it contributes -50 percent and negatively GDO in case of low income countries.

**Table 6: Findings of Penal Generalized Method of Moments (Low Income Countries – Model 1)**

S.No	Variable	Coefficient	Prob
1	R&D	0.28	0.02*
2	PA	0.21	0.00*
3	GCF	0.01	0.03*
4	GINI	-0.11	0.00*
5	PoP	-0.5	0.23
6	C	37	0

Note: \* denotes the 5 percent level of significance.

The findings reveal that in High income countries R&D has a considerable and adverse impact on the GINI. Result indicates that R&D causes reduction in GINI by 79 percent. The results are shown in Table 7 below:

**Table 7: Findings of Penal Generalized Method of Moments (High Income Countries – Model 2)**

Sr.No.	Variables	Coefficients	Probability
1	R&D	-0.79	0.01*
2	C	30.45	0

Note: \* denotes the 5 percent level of significance.

Table 8 signifies that R&D is insignificantly and negatively interrelated with GINI. Since the R&D spending is lesser in middle-income countries and resultantly experiencing considerable income disparity.

**Table 8: Findings of Penal Generalized Method of Moments (Middle Income Countries – Model 2)**

Sr.No.	Variables	Coefficients	Probability
1	R&D	-0.11	0.8
2	C	26.07	0

Note: \* denotes the 5 percent level of significance.

In accordance with the findings reflected in Table 9, it exhibits that R&D does not have a substantial impact on GINI in lower income countries. The results are inconsequential since low-income countries spend very little on R & D due to their small GDP and increased income disparity. Hence their impact is negligible. The results are portrayed in Table 9 below.

**Table 9: Findings of Penal Generalized Method of Moments (Low Income Countries – Model 2)**

Sr.No.	Variables	Coefficients	Probability
1	R&D	-0.1192	0.19
2	C	40.12	0.02

Note: \* denotes the 5 percent level of significance.

## 5 Conclusion

In High income countries, R&D and GINI contribute -23 percent and -10 percent in GDP respectively, while the results of Model 2 indicate that R&D causes reduction in GINI by 79 percent. However, in middle-income countries, innovation or R&D contributes only 4% in GDP and income inequality is adversely associated with GDP, which further implies that 2 percent reduction in GINI results 1 percent incline in GDP. It indicates that middle-income countries' innovation has little impact mitigating the income inequality. That is because research and development in middle-income countries are low, so does its contribution. Research and development has a 28 percent impact on GDP in low-income countries, while income inequality has reduced by 11 percent of GDP. Innovations, on the other hand, have a negligible effect on income inequality. According to Robinson and Acemoglu (2012), innovation (R&D) would be beneficial for those nations having quality human capital. This study suggests escalation of investment on R&D, which will have multifarious effects on economy by producing the employment avenues which will further reduce the income inequality and provide trajectory for the sustainable macroeconomic stability.

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