Research and Development and Education impact in Economic Transformation

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Abstract

Purpose: Education, Research and Development (R&D), and Information and Communication Technology (ICT) have emerged as crucial determinants of economic progress in the modern era. This research focuses on the economic transformation by examining the percentage of employees and its shift in the three economic sectors: agriculture, industry, and service sector.

Design/ Methodology: The study includes a diverse set of countries, totaling 30 countries, which are categorized into three groups consisting of 10 countries sharing a common classification. The model used for data analysis- Structural Equation Model, fit well and the results of the analysis show a relation among theoretical part and data analysis.

Findings: R&D, ICT and education plays a crucial role in shaping employment distribution across sectors and driving economic transformation. As economies evolve, labor is increasingly concentrated in the service sector, while agriculture is gradually diminishing in terms of both employment and its contribution to output. In contrast, the industrial sector is experiencing changes at a slower rate compared to these sectors, suggesting a more gradual transformation in its role within the economy.

Originality: The study enhances the existing knowledge in role of R&D, digitalization, and education in the economic transformation.

Keywords: *Economic Structural Change, Economic Transformation, R&D, Education, Information and Communication Technology.*

1. Introduction

Economic transformation has become evident in nearly all countries worldwide, particularly in recent decades. Economic structural changes analysis highlights various factors contributing to these changes, including the rapid advancement of Information and Communication Technology (ICT), education, investments in Research and Development (R&D), and innovation.

Economic structure refers to the composition and distribution of economic activities within an economy. It represents the relative contribution of different sectors, such as agriculture, industry, and services, to the overall Gross Domestic Product (GDP) of a country. By examining the economic structure, analysts can gain insights into the sectoral dynamics, resource allocation, and the overall productive capacity of an economy. Changes in the economic structure can indicate shifts in the relative importance and performance of different sectors, reflecting the evolving nature of economic activity.

On the other hand, the economic structure of the population pertains to the distribution of employment and workforce across various economic sectors. It provides information about the percentage and number of individuals engaged in agriculture, industry, and services. By studying the economic structure of the population, researchers can assess the labor market dynamics, employment trends, and the sectoral distribution of jobs within a country. Understanding the economic structure of the population is crucial for policymakers, as it helps identify areas of potential job growth, skill requirements, and the need for labor market interventions and policies.Both the economic structure and the economic structure of the population are important aspects of analyzing and understanding an economy's composition, performance, and potential for growth and development.

The objective of the research is to measure the impact of education, R&D and Information and Communication Technology in the economic transformation: transformation of economic sector population, that means changes in the percentage of employment by three economic sectors: agriculture, industry and services.

Research questions: How Education, R&D investments and ICT are impacting the changes in the number of employees in the economic sectors: agriculture, industry and services at world countries?

Scientific research on the topic of economic structural changes have used different approaches. The between-sector component of productivity growth (by sector and for the whole economy) is a measure of structural change contribution [1]. The study of structural changes by authors Muelhi and Gazalli, [1], take into consideration components of education, R&D investments and innovation. As the innovation and Information and Communication Technology – ICT is closely related, and actually one follows the other, the model was extended by including the ICT factors that are considered to have influenced the economic transformation of a country.

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2. Theoretical approach of structural changes

The theoretical approach to understanding structural changes in economies forms a key foundation for this study. Structural changes refer to the shifts in the relative importance and composition of different economic sectors within a given economy over time. Several theoretical frameworks have been developed to explain and analyze these changes.

Authors, Dudzevičiūtė, Mačiulis, & Tvaronavičienė [2], in their study find out that, according to some previous studies the economic sector changes can be measured based on the share of the output or employment. The proportion result of sector evaluation in terms of the current product or employment remains unchanged [3]. Broader explanation is given on the study of "Structural Change and Productivity Growth in the Japanese Manufacturing Industry" [4], on analysing the structural changes. According to them, there is wide range of indicators that economic structure changes could be analysed. Beside the employment concentration and added value, there are other approaches such as: income-elasticity, productivity growth, share of output in GDP, total spending cross-sectors etc. Authors Sah & Stiglitz [5] in their study, based on positive and comparative approach "The Architecture of Economic Systems: Hierarchies and Polyarchies" have been focused on setting out the framework for the economic systems alternatives, that can be evaluated and compared through performance. They concluded that, the optimum economic system is set by a set of external circumstances, thus the optimal organizational form of activities is chosen by the society.

In this aspect of economic sectorial development, by many authors were mentioned the technological changes implication on the employment. In another study, Joseph E. Stiglitz, emphasize the role of the technology adoption in the economic development. The technological development in agriculture, during the years of 1960s-1980s, according to Stiglitz, [6] was not foreseen in the Marx work, which Stiglitz see that these improvements adoption plays crucial role on country economic development and growth. According to [6], intention for technology adoption should be paid for the current or perspective profitability. Thus, aiming to the benefit by the adoption of the future technologies.

Innovation and industrial change relationship, was always among key topics in the Schumpeterian work, by putting the emphasis on the relation and impact that innovation have in the economic growth and change of the industry. Acceleration of economic sectors growth and emergence of the different sectors, increase of the competition among firms and those new comings with new products and technologies. The attention of the relation among innovation, and industrial dynamics was declined, by being focused also on the level of the innovation, firm size and composition and market structure.

On the other hand, innovation plays an important role also in the development of country in terms of investments, FDI, which are seems to be dependent on the level of the innovation within the host economy [7].

In this regard, “progress has been made at a more macro level, by linking innovation and industry evolution to structural change and the changing sectoral composition of the economy”.

A recent study, [8] analyzes data from five years period, respectively 2017 to 2022 using Structural Equation Modelling, shows a positive link between ICT and economic growth across 27 EU countries. Furthermore, finds that ICT growth has significantly impacted key sectors like research, education, and business, reshaping social and market dynamics. The main drivers connecting ICT development to GDP growth are identified as human capital, e-government, and digital technology integration [8].

Additionally, authors Gyamfi, Onifade, & Ofori conclude in their study that prioritizing investment in quality education and eco-friendly ICT infrastructure by governments and stakeholders supports a sustainable environment [9].

2.1 Methodology

In this dataset there were 30 states with a period of 29 years. For better comparison, the countries were chosen and divided in three groups of countries, each group was composed of ten countries that belong to the same category: first group of ten countries are worlds` countries with highest GDP, second group of ten countries are worlds` countries with highest GDP per capita, and third group of ten countries are Balkan countries.

Thus, this dataset that was used for analysis has 399 valid observations. The model use for analysis is Structural Equation Model. This model is used for socio-economic analysis, encompassing various methods to serve diverse purposes. According to the author Nokeri [10], the model has its features that are multivariate regression analysis, correlation analysis, covariance, and the investigation of variability. Consequently, the model fits to the purpose of the study, where it is used SPSS v26 and AMOS 21 for all the analysis and models presented in this paper.

Variable	
Agriculture share (% of total employment)	ae
Manufacture share (% of total employment)/ Industry	ie
Services share (% of total employment)	se
Average Years of Schooling	aye2
R&D spending	rde

Patents	pattenth
Hi-tech exports	htex
Computer Hardware spending	hsthenth *values for ICT are in then thousand
Computer software spending	sosthenth
Service spending	serstenth
Communication spending	comstenth

Table 1 Description of variables
(*Source: Author's description*)

Below is presented the model used for analysis: Model of the Economic Structure through SEM

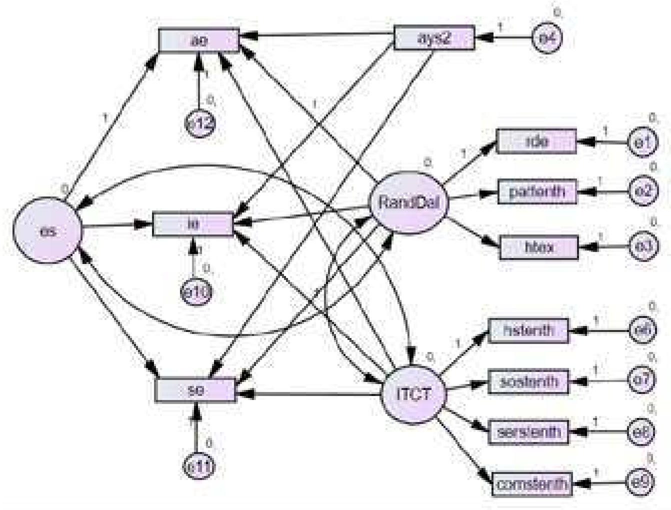

Figure 1 Model of the Economic Structure through SEM
(*Source: Author's illustration*)

The Structural Equation Modelling (SEM) method, which is supported by also by [8], is used to test our main hypothesis, which is that ICT has a positive and enhancing effect on economic progress.

Descriptive Statistics

		Minimum	Maximum	Mean	Std. Deviation	Variance	Skewness		Kurtosis	
	Statistic	**Statistic**	**Statistic**	**Statistic**	**Statistic**	**Statistic**	**Statistic**	**Std. Error**	**Statistic**	**Std. Error**
ae	849	0.19	59.70	10.14	11.82	139.74	2.14	0.08	4.44	0.17
ie	850	10.76	45.99	25.65	5.95	35.35	0.24	0.08	0.01	0.17
se	850	17.88	87.85	55.67	19.53	381.30	-0.47	0.08	-1.15	0.17
rde	659	0.02	4.55	1.68	0.91	0.82	0.26	0.10	-0.53	0.19
Pattenth	696	0.00	140.00	4.15	12.52	156.69	5.98	0.09	47.74	0.19
htex	736	0.05	98.73	16.96	12.49	155.98	1.90	0.09	6.66	0.18
hstenth	463	0.01	16.92	1.54	2.85	8.12	3.45	0.11	12.39	0.23
sostenth	462	0.00	15.20	0.94	2.17	4.71	4.41	0.11	20.49	0.23
Serstenth	462	0.00	43.15	2.20	5.54	30.65	4.85	0.11	25.73	0.23
comstenth	462	0.01	52.56	4.94	9.03	81.54	3.13	0.11	10.23	0.23
ays2	783	1.20	14.10	10.49	2.23	4.98	-1.75	0.09	4.80	0.18
Valid N (listwise)	399									

Table 2 Descriptive statistics of variables
(*Source: SEM results*)

From the descriptive statistics we see that the number of observations is quite high for the first variables (around 850), then it is decreased to (around 650-700) and the lowest value is for the last variables in the table (around 460). As regard to the standard deviation, it is not that high. The largest is 19.53 for se, then 12,52 for patentth and almost the same 12.49 for htex while the lowest value is 0.91 for rde.

3. Results

Composite Reliability (CR) analyses has been done as a further model fitness indicator (which is more reliable than Cronbach's alpha), the latent variable RandDal and ITCT have values are greater than 0.6, which again confirms the strength of the sub-variables in the latent variable. Here also the Convergent Validity (CV) through the Average Variance Extracted (AVE) is presented to measure total amount of the variance of the indicators collected by the latent variable, the results are presented in the table below, and we can see that every latent variable is greater than 0.5 which means the sub-variables are a good representative for the latent variables. Lastly,

Discriminant Validity (DV) is to indicate and argue the presence of the latent variables, which is that each value here must be greater than the correlation values, in our case all the variables have greater DV then the correlation factors.

Constructs	Indicators	CR	AVE	DV
RandDal		0.60	0.35	0.59
	rde			
	pattenth			
	htex			
ITCT		0.97	0.90	0.95
	hstenth			
	sostenth			
	serstenth			
	comstenth			
RandDal		0.01	0.01	0.10
	ae			
	ie			
	se			

ITCT		-3.27	6.46	2.54
	se			
	ie			
	ae			
ays2		0.11	0.14	0.38
	ae			
	ie			
	se			
es		-2.78	7.05	2.66
	ae			
	se			
	ie			

Table 3 Structural Equation Model regression weights
(*Source: SEM results*)

Analysing the model fit of our model we can see that we have a CFI index of 0.746, and RMSEA of 0.202, all of these indexes presents that this model is fairly fitted model.

The Regression Weights results are presented in the table below:

			Estimate	S.E.	P-Value
rde	<---	RandDaI	1		
pattenth	<---	RandDaI	7.131	0.927	***
htex	<---	RandDaI	9.625	1.023	***
hstenth	<---	ITCT	1		
sostenth	***	ITCT	0.801	0.016	***
serstenth	***	ITCT	2.03	0.041	***
comstenth	***	ITCT	3.017	0.089	***

ae	***	RandDal	1		***
ie	***	RandDal	-0.76	0.814	0.351
se	***	RandDal	3.56	2.232	0.111
se	***	ITCT	2.591	0.815	0.001
ie	***	ITCT	1		***
ae	***	ITCT	-18.279	27.998	0.514
ae	***	ays2	-2.579	0.146	***
ie	***	ays2	-0.819	0.088	***
se	***	ays2	2.277	0.289	***
ae	***	es	1		***
se	***	es	-0.149	0.22	0.496

Note: (*p<0.05, **p<0.01; ***p<0.001)

Table 4 Structural Equation Model regression weights
(*Source: SEM results*)

From the results, we can clearly see that, if the percentage of the rde (R&D spending), patthenth (number of patents issued) and htex (Hi-tech exports) are increased for 1, the RandDal will get higher results and these finding are highly significant, based on the p value.

The increase of hstenth (Computer hardware spending), sostenth (Computer software spending), serstenth (Service spending) and comstenth (communication spending) for 1, the ICTC will get higher results too. The p value shows that the result are highly significant.

The increase in Research and Development spending (RandDal) by 1 will result in lower employment in the industry (ie). Conversely, the increase in Research and Development spending (RandDal) by 1 will lead to higher employment in services (se). This means that higher investments will reduce the number of employees in the agriculture sector and increase employment in services.

Regarding the impact of ICTC on the economic structure of the population, the results from the analysis show that a 1-unit increase in ICTC will result in lower employment in agriculture (ae). Conversely, it will have a different effect on employment in the service sector, with a 1-unit increase in ICTC leading to higher employment in services.

The last indicator measured is the average years of schooling. Its impact on the economic structure of the population is as follows: a 1-unit increase in ays will result in lower employment in agriculture (ae) and lower employment in industry (ie), while a 1-unit increase in aye will lead to higher employment in services (se).

As for the correlation, the results show that agriculture and industry have a positive correlation, meaning that if employment increases in the agriculture sector, it will also increase in the industry sector and vice versa. The correlation between agriculture and the service sector is negative, indicating that if employment increases in

agriculture, employment in services will decrease. Regarding investments in R&D, there is a positive relation with patents. Hence, an increase in investment in R&D will lead to an increase in the number of patents.

Original Hypothesis	Regression Impact	Results
H1: Education has negative impact in agriculture employment	Negative	Supported
H2: Education has negative impact in industry employment	Negative	Supported
H3: Education has positive impact in employment of service sector	Positive	Supported
H4: R&D and innovation has positive impact in agriculture employment	Positive	Supported
H5: R&D and innovation has positive impact in industry employment	Negative	Not supported
H6: R&D and innovation has positive impact in service employment	Positive	Supported
H7: ICT has negative impact in agriculture employment	Negative	Supported
H8: ICT has positive impact in industry employment	Positive	Supported
H9: ICT has positive impact in service employment	Positive	Supported

Table 5 Regression impact of hypothesis
(*Source: Author's illustration*)

Empirical Analysis: Education, R&D Investments, and ICT Impact in the Economic Structural Changes - Economic Transformation,' presents the econometric results from the empirical analysis. The results, obtained using the Structural Equation Model, highlight the significance of the model and its relation to both the empirical and theoretical parts. The Structural Equation Model used for data analysis fits well, and the results show a relationship between the theoretical framework and the data analysis.

Furthermore, the hypotheses raised were mainly supported. More specifically, the results of the analysis show that only one hypothesis is not supported, while the other eight are supported.

4. Conclusion

The economic transformation in the study is analysed through the perspective of the economic structure – output and the structure of the population, specifically the share of employment in the economic sector. As the division is large and detailed in terms of economic activities, the authors have grouped related economic activities into larger categories. More recently, authors have distinguished sectors while grouping them into three main categories, including groups of industries: a) Primary sector: activities related to natural resources, such as farming, oil extraction, mining. b) Secondary sector: activities related to the production of goods and processing of materials. The main activity in this sector is manufacturing, which includes construction and utility industries like electricity, water, and gas. c) Tertiary sector: activities related to services such as banking, finance, insurance, health services, defence, and distribution.

The results of the analysis show that, out of eight hypotheses only one hypothesis is not supported. All other hypotheses are supported.

The study provides insight into new developments and trends in education, ICT, and digitalization. Additionally, it offers information on the change in the economic structure of the population, indicating a path toward economic transformation and, consequently, economic growth. The provision of evidence for the impact of education, R&D, and ICT on the economic transformation of the population, employment in declining sectors, labour mobility challenges, and an analysis of the tendency toward technological unemployment and technical progress makes the study valuable not only for policymakers but also for enriching theoretical and empirical literature.

Research and development (R&D), ICT and education plays a crucial role in shaping employment distribution across sectors and driving economic transformation. As economies evolve, labor is increasingly concentrated in the service sector, while agriculture is gradually diminishing in terms of both employment and its contribution to output. In contrast, the industrial sector is experiencing changes at a slower rate compared to these sectors, suggesting a more gradual transformation in its role within the economy.

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