HUMAN CAPITAL AND INNOVATION : An analysis for countries at different levels of technological development (2000/2012)

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THEORETICAL FRAMEWORK

- Economic development/growth
  - **Endogenous Growth Theory:**
    - Human capital
  - **Schumpeter:**
    - Innovation

SCHUMPETER

- Economic life from the perspective of a circular flow undergoes discontinuous changes. The changes would be the characterization of the economic development process that could be described by introducing factors that were not part of the economic relations.
- **Schumpeterian entrepreneur was the responsible for the changes:** he is the one who learns, performs and concludes new combinations (**innovations)**.
  - Who is he???
    - He does not need to have ties to the company. He is not a leader or a business manager (capitalist)
    - It is his talent and conduct that awakens the attention of capitalists and bankers (financiers of innovation)
    - He has no social class and profession, but his success certainly would lead him to certain class positions; as the capitalist or the owner of the business.

More entrepreneur → More innovations → more growth

ENDOGENOUS GROWTH THEORY

- Harrod (1939) and Domar (1946): the main determinants of growth are investment (physical capital) and workforce.
- Solow (1956) adds the rate growth of technology to the Harrod-Domar model: work and technology grow at constant and exogenous rates over time.
- During 1980 arise the endogenous models that treat technical progress as an endogenous factor.
  - **Knowledge accumulation** explains the growth differences between countries.
    - Arrow (1962): Learning is a product of experience and is acquired in repetition in order to produce a particular good, the **learning-by-doing.**
    - Romer (1986): the accumulation of knowledge comes from the **physical capital accumulation**, which enables to produce goods more efficiently.
    - **Disability:** do not explain how the human capital spreads in the economy

ENDOGENOUS GROWTH THEORY

- Lucas (1988) consider the investment in human capital the reason of the positive externalities (spreading) by increases in the level of technology.
- Human capital is a cumulative factor: **is the sum of skills of individuals given through social activities involving groups of people; something that is built into the individual.**
  - Human capital accumulation can be achieved through the **education** and also by specialized human capital through **learning-by-doing,** the knowledge acquired with practice.

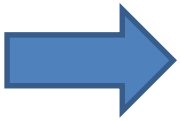
More human capital ⇨ more technology/productivity ⇨ more growth

HYPOTHESIS

- Schumpeter does not address the formation of the innovative entrepreneur (who is he ??? what is his profession ???). Would have prerequisites to form him, since his role is crucial for economic development?
- He is a professional with stock of knowledge, as indicated by the endogenous growth models?
  - **More specifically - the Schumpeterian entrepreneur who modifies the structure of an economy through innovation can be compared to the human capital of the endogenous growth theory, that with his stock of knowledge, increases labor productivity and generates development?**

GOAL

- Check the relationship between **Human capital** (Endogenous Growth Theory) and **Innovation** (Schumpeter) for **technologically developed countries** (Group 1) and **technologically underdeveloped countries** (Group 2) by developing an econometric model for the period 2000 to 2012

More human capital  **more innovations**

DATA BASE

- **Dependent variable**: Patent Applications (Inpat) - **Innovation**
  - Expected innovative entrepreneurs and firms competing to obtain patents, so through technological advantage achieve profit
- **Explanatory variables**: expected positive sign with the dependent variable
  - **Average Education of population > 25 years (Inescola):proxy of human capital**
    - Higher level of education allows higher growth rates of human capital and greater use of manpower in high-tech firms.
  - **Annual gross domestic spent of the countries in R&D (Inpd1)**
    - Expenditures on R&D (lagged one year) means investment for creation of innovative products in the future.
  - **Foreign Direct Investment – FDI (Inied)**
    - Important for the encouragement of the local patent system
  - **Saver gross of countries as a percentage of GDP (Inpoup)**
    - Savings influences the bank credit that has relation with the innovative process
  - **Workforce (Inftrab)**
    - Economy with a high degree of occupied population generates effect on urbanization, which generates externalities stimulating competition.
  - Formally the model can be presented by the equation:

$$Patents = \beta_{0i} + Education\beta_1 + R\&D\beta_2 + Saving\beta_3 + FDI\beta_4 + workforce\beta_6 + \varepsilon_{it}$$

GROUP OF COUNTRIES

- Countries were divided into two groups according to the global ranking of patent applications (PCT): average of 2000 to 2012
- **Group 1: Countries technologically developed** - 78%
  - United States, Germany, France, Japan, Switzerland, the Netherlands and the United Kingdom.
- **Group 2: Countries technologically underdeveloped** - 22%
  - Sweden, Italy, Canada, South Korea, Finland, Belgium, Australia, China, Spain, Denmark, Norway, Israel, Austria, India, Brazil, Ireland, South Africa, Luxembourg, New Zealand, Mexico, Singapore, Russia, Portugal , Hungary, Greece, Czech Republic, Turkey, Argentina, Belarus, Chile, Poland, Colombia, Saudi Arabia, Malaysia, Iceland and Malta.

DESCRIPTIVE ANALYSIS

- Group 1: higher averages for all variables
  Group 2: great heterogeneity
  - Maximum values show that this is composed of some countries that have similar characteristics to the group1.
  - Minimum values confirm opposite characteristics
  - Amplitudes and the standard deviation are higher

Initials	Grupo 1					Grupo 2				
	Average	Minimun	Maximun	Standard Desviation	Obs.	Average	Minimun	Maximun	Standard Desviation	Obs.
lnpat	7,00795	5,8636	8,9316	0,8296	91	3,3343	0	6,4892	1,6969	450
lnescola	2,440	2,2544	2,5967	0,0931	91	2,2604	1,4838	2,5771	0,2313	458
lnpd1	18,00	15,9061	23,6	2,4161	79	16,6038	9,3323	24,633	2,5031	407
lnied	13,27	10,7388	15,0828	1,0599	91	11,2482	6,2095	13,7825	1,4201	443
lnpoup	3,14	2,5059	3,6635	0,2686	91	3,1228	1,1521	3,9768	0,3801	465
lnftrab	10,24	8,2914	11,9948	1,1279	91	8,9847	5,0663	13,6076	1,828	455

METHODOLOGY: Panel data

- To check the impact of human capital in innovation it is used the method of Ordinary Least Squares (OLS) with random and fixed effects.
- To select the best model it is used **Breusch-Pagan and Hausman test.**
  - To verify the existence of **unobserved effects**, carried out the **Breusch- Pagan test by Lagrange multiplier**, which tests the null hypothesis of non-existence of unobserved effects.
    - In rejecting the null hypothesis shows the existence of unobservable specific effects of the countries. It is not interesting POLS model for estimation.
  - To correct the possible **endogeneity** problem, the model is estimated with fixed and random effects.
    - To compare which model fits best, it is held the **Hausman test**. The test compares the consistency of the estimators of the models, testing the null hypothesis of the presence of random effects.
    - In rejecting the null hypothesis, the most recommended model is the fixed effects, and not the random effects.

RESULTS

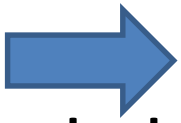
- **Group 1:** Breusch- Pagan test indicates the POLS model.
  - All variables have estimators statistically significant and expected relationship. The coefficient of the variable Average Education of the Adult Population (lnescola), human capital proxy, shows positive and significant in relation with Patent Aplications (lnpat), proxy for innovation of the countries, and is the biggest of the regression .
    - Coefficient 2: % variation in human capital has doubled impact on the level of innovation
- **Group 2:** Breusch- Pagan and Hausman tests indicate the Fixed Effects method.
  - The coefficient of lnescola variable is not significant to explain the innovation. Despite all the variables had expected relation, only Foreign Direct Investment (lnied) and Workforce (lnftrab) are significant (99% confidence).

Nome	Grupo 1	Grupo 2
lnescola	2	1.683
	(4.33)**	(1.27)
lnpd1	0.086	0.05
	(2.36)*	(1.54)
lnpoup	1.653	0.139
	(8.52)**	(-0.90)
lnied	0.613	0.309
	(9.29)**	(3.07)**
lnftrab	0.37	3.28
	(4.65)**	(3.37)**
_cons	-16.599	-34.162
	(-14.44)**	(-4.57)**
R^2	0.85	0.5
N	79	358

*$p<0.05$; **$p<0.01$

CONFIRMATION OF THE HYPOTHESIS

- R-squared of the regression:
  - **Group 1:** 85% of the sample variation of patent applications can be explained by the regression variables.
  - **Group 2:** Only 50%
- **There is statistical evidence to confirm the hypothesis, at least for countries in Group 1 (technologically developed countries) there is relevance of educational qualifications (human capital) in generating scientific and technological innovations .**

More human capital  **more innovations**

- In Group 2 (**technologically underdeveloped countries**) the human capital estimator may have been negatively influenced by:

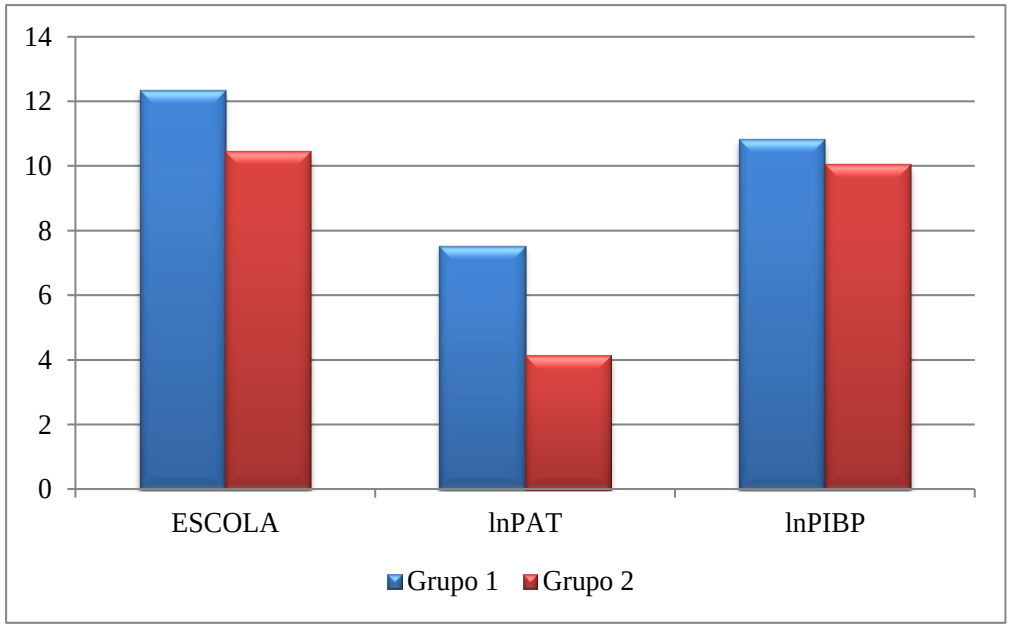
i) internal heterogeneity of the group;
ii) large population of most countries;
iii) significant changes in the educational level of the adult population are slow

CONCLUSION

- When comparing the average schooling of the adult population (Inescola), proxy for human capital, the logarithm of Patent Aplication (lnPAT), proxy for innovations, and the logarithm of GDP per capita (lnPIBP), grown, of the groups of countries in 2012 it appears that Group 1 stands in all the variables.

More human capital → more innovations

→ more development/growth



THANKS

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