New Trends and Issues Proceedings on Humanities and Social Sciences

Issue 5 (2016) 170-176

Selected paper of 4th Cyprus International Conference on Educational Research (CYICER-2015) March 19 – 21, 2015, Girne American University in Kyrenia, CYPRUS

Regional differences in Italian students' performance: a simulation model

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Suggested Citation:
Costanza, F., Gentile, M., Seta, L., Pipitone, V., Vassallo, E. & Allegra, M. (2016). Regional differences in Italian students' performance: a simulation model. *New Trends and Issues Proceedings on Humanities and Social Sciences.* [Online]. 05, pp 170-176. Available from: www.prosoc.eu

Selection and peer review under responsibility of Assist. Prof. Dr. Cigdem Hursen, Near East University

Abstract

This work presents the first results of a research project seeking to build a simulation model able to reproduce the differences of Italian students' performance at regional level. A preliminary qualitative cause-and-effect model defines the main variable involved in the inter-generational skill formation processes, as well as their interplay with the job market context and the triggering of motivational forces for new skill acquisition. Such model was designed according to a system dynamics perspective, considered suitable for capturing the interrelatedness of key variables and for providing useful simulation tools to conduct and communicate future scenario analyses.

Keywords: regional difference; educational achievement; system dynamics; PISA;

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1. Introduction

This study aims to contribute to the explanation of the students' performance inequalities among Italian regions, by adopting an innovative simulation approach based on system dynamics (Forrester, 1958, 1969; Richardson, 1991; Sterman, 2000, 2014).

The differences of students' achievements in southern and northern Italy are well known in literature, with regional gaps increasing in pace with the educational career advancement (Bratti, Checchi & Filippin, 2007; OECD, 2012; INVALSI, 2013; Seta, Pipitone, Gentile & Allegra, 2014; Matteucci & Mignani, 2014).

The study of the causes of differences in students' scores has a long history, and many factors has been highlighted, according to level of analysis (Hanushek and Woessman, 2011). At individual level, starting from the work of James Coleman and colleagues (Coleman et al. 1966), the influence of family background on the educational achievement of students has been investigated.

In this regard, particular attention was devoted to the motivational factor. According to Grolnick and colleagues. "*a focus on motivation is consistent with an active model of children, whereby they are not passive recipients of inputs from the social context, but active interpreters of the context as they develop motives and concepts of themselves that they then bring to achievement settings*" (Grolnick, Friendly, & Bellas, 2009).

In the same article (Grolnick, Friendly & Bellas, 2009) the authors analyze the relationship between family background and motivation of the students in the light of different motivational theories such as the Self-determination Theory (Deci & Ryan, 1985), the Expectancy-Value theory (Eccles-Parsons et al., 1983), and Goal Orientation Theory (Dweck & Elliott, 1983).

This study allowed to deepen the comprehension of the relationship between family background and students' educational achievement, whose analyses are often undertaken by only referring to socio-economic factors, like credit constraints and family income (Becker and Tomes, 1979; Aiyagari, Greenwood & Seshadri, 2002; Benabou, 2002). Moreover, the type of involvement and strategies adopted by parents also determine which type of motivation is developed. Parents who support children independence implicitly favor an intrinsic motivation unlike to parents whose behavior is perceived by children as a "control" mostly operating at a level of extrinsic motivation. Furthermore, it cannot be disregarded the ability of parents to organize a "favorable" environment for the success of their children, what Grolnick and collegues (Grolnick, Friendly & Bellas, 2009) define as structure, i.e. the parents' set of rules, guidelines and expectations on the children.

Although many processes and conditions supporting the students' motivational development are now known, further research will be necessary in order to capture the complex relationship among the traditional income-based and the motivational-based approaches. To this aim, we build on the model about the technology of skills formation (Cunha, Heckman, & Schennach, 2010), which introduces students' skills (cognitive and non-cognitive) as stocks accumulating according to a production function dependent on the students' skills previously accumulated, parental skills and investment. This model lays at a general level without giving the possibility to investigate regional differences: the only way to do that is to adopt exogenous shocks in the model. Our move is to endogenize the effect of contextual variables, using the parental skills as a proxy for the human capital (determining the labor conditions) and introducing the impact of the variable motivation on the skill formation.

After a brief introduction about system dynamics and its applications in educational sector, the paper presents a preliminary insight model depicting the main interrelations between the key-variables involved in the skill formation mechanisms.

2. Brief introduction to system dynamics and applications to education

According to Conte et al. (Conte, Gilbert & Sichman, 1998), simulation is a research tool that reproduces a real system or process by means of an artificial system and provides useful and often essential insights into a large number of scientific and application sectors.

System dynamics was evaluated as a suitable simulation approach to address the skill formation topic as it applies to dynamic problems (e.g. problems that involve change over time) arising in complex social, managerial, economic, or ecological systems, literally any dynamic systems characterized by interdependence, mutual interaction, information feedback, and circular causality (Richardson, 1991).

In system dynamics, the structure of a complex system can be conceptualized by stock-and-flow diagrams, which represent the physical structure of a system, tracking accumulations of material, money and information. Two kinds of building blocks constitute these diagrams: stocks or accumulations (levels, identified with certain units) and flows (rates, identified with units per time).

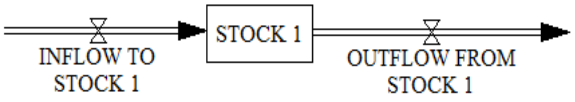

Fig. 1. Simplified Stock-and-Flow structure.

Systems therefore consist of networks of stocks and flows linked by information feedbacks from the stocks to the rates. As stock accumulates their inflows less their outflow, thus a stock and flow structure quantitatively can be represented as a system of integrals and differential equations (Sterman, 2000).

Previous application of system dynamics in education addressed education management issues both in primary (Clauset & Gaynor, 1982; Lopez, Guevara & Zuniga-Saenz, 2005) and higher educational levels (Barlas & Diker, 2000). Notwithstanding, the process of skill formation was specifically addressed at firm's level (Diawati, Kawashima & Hayashi, 1994; Winch, 2001).

So far, this is the first time in which system dynamics is proposed to address the technology of skill formation during the educational stages of life (before entering in the labor market).

3. The model

The present section describes the model in figure 2. In this preliminary version of the system dynamics model, we focused on the definition of the main variables and cycles of interaction between them.

The model structure is made of seven main stocks, whose interaction is supposed to give rise to the behavior patterns of a regional system, thereby rebuilding, for now at a qualitative level, the difference in students' performance characterizing the Italian regions.

The cause-and-effect structure captures two basic mechanisms: (1) the inter-generational process of skill formation and transfer, (2) the impact of elements of the context, in particular related to the labour market's conditions, over the technology of skill formation.

The students' skills (distinguished into the stocks of cognitive and socio-emotive) get into parental ones, as they enter the adulthood stage of life and are supposed to give bird to new generations.

In the presented model, two main forces influence the students' skill process of accumulation: the parental skills and parental financial investments. Indeed, the impact of parents' skills and choices of investments on the children results, both in terms of skills acquired and qualification attained, is widely debated in the literature. These figures are linked to the theme of equality of opportunity (EoO), often approached by analyzing how the family social background affects the children achievement, in terms of skills and careers (GERESE, 2005; Benadusi & Giancola, 2014). As reported by Cunha and Heckman (2007): "children from disadvantaged families may suffer from a lack of resources invested in them, or they may have parents that lack the information necessary to make adequate investments in their children, even if resources are made available (for example, through state programs), because of poor education. It is easier to compensate for low current funds (if parents borrow against future consumption to finance current investments in their children) than against low parental human capital" (Cunha & Heckman, 2007).

The parental cognitive skills influence the labor market conditions, which in turn provide informative inputs likely to affect the investments in students' education and the socio-emotive and cognitive skills formation. The labor market conditions also affect the stock of NEETs (Not engaged in Education, Employment or Training) and by this way the aggregated motivation. The latter has an impact on the students' cognitive skills, which feed back into the labor market conditions due to generational interplay.

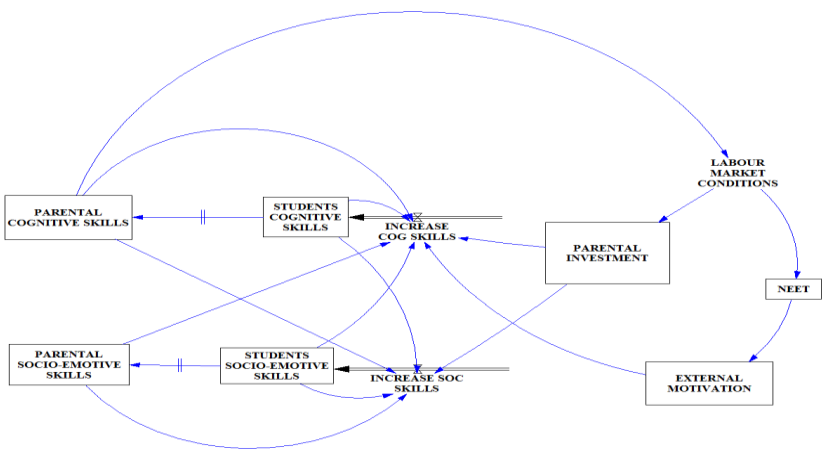

Fig. 2. Skill formation insight model

In the model, the motivation is one of the determinants of the students' achievement, both by modulating the commitment to specific levels of skills achievement and by affecting the decision-making processes about the use of resources for the completion of subsequent cycles of education. It

is true that the motivational factor acts on an individual level; therefore, it is difficult to propose its use within the system dynamic approach, which rather captures processes of accumulation. Thus, in this case it is more appropriate to talk about the formation of some contextual factors that combined to the characteristics of the subjects (however measured at an aggregate level), result in a "motivational climate". The latter can be defined as an environment where the contribution of motivational forces in the decisions of cognitive skills acquisition may change over time and in turn can be determined by specific interactions with other environmental factors.

4. Conclusions

In the model proposal, we identified some key variables whose interaction is supposed to give a qualitative explanation to the difference in students' performance characterizing the Italian regions. The analysis was carried out from a system dynamics perspective, which gives rise to models that "are feedback based, they deal with systemic problems at an aggregate level over time and postulate causal relationships as result of a cognitive abstraction" (Sholl, 2001). As a result, a number of limitations laying in the process of model boundaries' selection can be envisaged. First, the main variables involved in the skill formation process operate at an aggregate level, without emphasizing that the different stages of the life cycle are critical to the formation of different types of ability, e.g. the non-cognitive skills are more malleable than the cognitive ones at later ages (Shonkoff, & Phillips, 2000). Second, the model does not take into consideration many factors that may interact with the family background as moderator or mediator on the students' performance, e.g. the quality of the school systems and teaching, the action of selective mechanisms that determine uneven distribution of pupils among schools, the level of competition between schools (Ponzo, 2011; Agasisti, 2011).

Next steps in System Dynamics modeling will be the identification of calculating variables and flows influencing the defined stocks. The resulting model, placed in a simulation software, will be aided by a set of differential equations, representing the main relationships between the selected variables, and populated by data from OECD Pisa reports and ISTAT (Italian National Institute of Statistics). Thus, by using simulations, the model is expected to provide predictions about key variables behavior pattern for different scenarios, also capturing the inter-regional migration dynamics triggered by the labor market conditions.

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