CENTRE D'ETUDES
ET DE RECHERCHES
SUR LE DEVELOPPEMENT
INTERNATIONAL

SERIE ETUDES ET DOCUMENTS

Human capital productivity and uncertainty

Mbaye DIENE

Bity DIENE

Théophile T. AZOMAHOU

Etudes et Documents n° 08

Avril 2015

CERDI
65 BD. F. MITTERRAND
63000 CLERMONT FERRAND – FRANCE
TEL. + 33 4 73 17 74 00
FAX + 33 4 73 17 74 28
www.cerdi.org

Abstract

Several policies or interventions have been implemented in developing countries with the ultimate goal of improving educational outcomes and human capital. While lots of empirical studies have pointed to mixed results of these interventions, the role of uncertainty arising from the state of the nature about educational environment, household characteristics, along- side the efficiency of these interventions still lack economic mechanism. This paper aims at developing a theoretical framework that links policy interventions to educational outcomes. We characterize optimal policies and determine the conditions for enhancing social welfare. We also study the optimal growth of the economy under uncertainty and population heterogeneity when human capital is produced and used in the education sector. We show that the growth rate of the unskilled population has a direct impact on the growth of human and physical capitals.

Key words: Educational outcome, policy interventions, social welfare, skilled and unskilled labor, endogenous growth

JEL codes: [JEL], [JEL]

Acknowledgment

We are deeply indebted to anonymous referees for their helpful comments. Insightful comments from Hibret Maemir and Hassen Wako are gratefully acknowledged. This work was supported by the Agence Nationale de la Recherche of the French government through the program “Investissements d’avenir ANR-10-LABX-14-01”. Théophile T. Azomahou thanks the support of UNU-MERIT. All views expressed as well as any errors are our own.

support policies.[5]

Risk aversion: Risk aversion is an important factor that inhibits the ability to innovate and it has implications on the extent to which any educational policy targets the appropriate conditions for interventions.

Shared visions: Refer to common perceptions of goals and requirements.[6]

Regardless of the approach adopted, the issue raised by policy interventions in education can be stated as follows: How does uncertainty affect the impact of policy interventions in the developing world? Indeed, in these countries, education is increasingly a crucial ingredient for development programmes. The role of uncertainty may come through different facets. In general, it is related to the state of nature, meaning exogenous factors unrelated to the policy that may affect the policy implemented. In developing countries, uncertainty is much more pronounced due in particular to the lack of resources and the level of development that ultimately can impact on the success of interventions. For example, it is common to observe that after the starting of implementation of an intervention at a given date, resource constraints are changing the object of the intervention, reduce its ambition, or sometimes even stop it.

This paper aims to develop theoretical frameworks to link every specific type of new intervention for each stakeholder to the global performance of education, taking into account the social welfare maximization problem. We consider the production function of the school as a black box where several factors combine (good school management, quality of school services and access to education) and whose outcome is the final performance of students. Our goal is to evaluate the evolution of this performance over time, when policy makers rely on the quality of the school production, e.g. educational outcome. Their interventions consist of changing the performance from an initial period to a final period, taking into account the constraints that may arise. To do this, we first link the vector of performance to the vector of constraints, assuming different types of relationships between these vectors.

In a first specification, we consider linear and nonlinear deterministic relationships and characterize the optimal interventions which give the best performance given the constraints and initial conditions. Then, recognizing that the lack of information on the socioeconomic characteristics of students and the educational environment in which interventions are implemented, among others, are uncertainty factors that may impede the achievement of performance objectives, we introduce uncertainty in the framework. Here again, we consider linear and nonlinear approaches. We find out the optimal conditions under which actions can be taken. Furthermore, we enlarge the analysis to the question of how the performance of the educational system can be integrated into a macroeconomic performance (in terms of well-being and economic growth).

Several results emerge from this study. Firstly, we consider the benchmark framework without uncertainty. In this set up, we consider both the linear and the nonlinear cases. For the linear model, we assume that the relationship between changes in performance and successive interventions are additive and separable. We study the growth rate of educational performance, their trend and the average change in performance due to a specific intervention. The main result is that interventions that allow to move from one level of initial performance to a final level are also additive and linear, and ultimately they may be constant in a regular time intervals. They also depend on the temporal growth rate of performances, that would have prevailed if there was no response. For the nonlinear model, we have shown that interventions are possible, even in the case of resistance, meaning factors that preclude performances. These interventions can be coordinated, so common to all stakeholders.

Further, we illustrate these findings with some examples. In the first, interventions can fade over time, which means that students at a given date can be left at their free course, when they reached a sufficient level of performance which is high enough to be irreversible. In the second example, the intervention depends linearly on initial conditions in regular time intervals. This means that interventions are implemented gradually, until the desired level of performance is reached. In the last example, only one type of intervention is made to achieve the desired the performance, regardless of which decision maker applies it.

Secondly, the framework with uncertainty also considers linear and nonlinear probabilistic models. The occurrence of random events is integrated. Relying on normal distribution of random events, we express the optimality conditions of interventions, based on average probabilities. We propose a methodology to solve these conditions. The optimality is based on maximizing the probability of achieving the target performance from an initial period to the final period. We illustrate in an example how the construction of solutions relies on the correlation function of the random process and the initial conditions.

Thirdly, we link the performance levels to social welfare, on the assumption that the ultimate goal of policy makers is improving the well-being of all individuals. This can go by investing in education of students. As in the previous case, we use deterministic and probabilistic approaches. Taking the expected utility of consumption and investment in quality and access to education, we show analytically the optimality conditions of these variables.

Lastly, we deal with economic growth with heterogenous population. Skilled and unskilled groups have different demographic dynamics. The economy has two sectors: education and production of goods and services. We show that the demographic growth rates of the two populations have differentiated impacts on economic growth.

The remainder of the paper is organized as follows. Section 2 introduces a brief review of the educational production performance. Section 3 develops frameworks of interventions in education. Section 4 studies the optimality of interventions in terms of social welfare. Section 5 addresses the issue of global approach of interventions with heterogeneous populations and their dynamics on economic growth under uncertainty. Section 6 concludes the study.

2 Education performance: A brief review and empirical facts

The goal of achieving universal education in developing countries involves looking for ways to produce effective and efficient schools. Effective teaching methods, based on survey data acquired from schools, have shown their worth for almost fifteen years. In order to identify forms of effective schools, tools were developed primarily to measure whether countries can achieve the goal of enroling all the children of school age, and then to evaluate the effectiveness and quality of learning provided in schools.

Since the 1990s, PASEC has implemented in Francophone Africa, surveys to assess child learning, collecting information on their characteristics: origin of children, their living conditions (situation at home, medical, diet, economic well being of household, housing quality, parental care etc), characteristics of teachers and schools, etc. These elements are often used as components of a production function of school (Bourdon, 2005). The problem is whether there is a form of this function that is appropriate to describe the effective provision of universal education and the performance of interventions in the education sector. A key challenge remains in describing the cost of education.

2.1 The production function of school

The identification of the determinants of quality educational service is not trivial. Hanushek (1986) shows that there is a bewildering range of issues including technical and esoteric conflicting results on the production process of the schools. He argues that there is still no clear answer as to what are the factors that influence pupils' performance. In this context, Pritchett (2001) finds that the choices that guide an educational allowance are not often based on academic performance.

Empirical facts contradict the hypothesis of an efficient allocation of resources that seeks to maximize the school performance. This contradiction is attributed to four reasons. First, the school is not a black box within which production technology follows market rules. Secondly, the impact of schooling on the attainment may be small compared to the role and importance of innate abilities of learners. Third, the demand for education is not facing a market, and the production function cannot be observed effectively from an economic standpoint. Finally, the education production function, if it is tested econometrically, cannot be generalized as already shown by Hanushek (1986).

2.2 Measurement of education effectiveness

The optimal timing of school programs has been studied by Farrell (1957) and Charnes et al. (1981). However, the difficulty lies in identifying stable parameters of the production function, most importantly those driven by the environment of school as well as households' characteristics. The school production is represented by the results of pupil assessment in language, calculation, the value of self-esteem reported by the pupils and also some more aggregate measures like enrollment, promotion, dropout, etc. For instance, Battese and Coelli (1995) show that the environmental variables can explain the remoteness of the border. Empirical studies are also interested in identifying the best performing schools. Relying on parametric and nonparametric approaches for envelope method, Cooper and Cohn (1997) have identified schools that are close to the efficiency frontier. The impact of intervention on the effectiveness of school have been examined as well by Stiefel et al. (1999) using randomized control trials. The authors show that there is a strong inertia between interventions and their effects on academic performance. Klein (2007) used a Becker-Stigler-Peltzman like model to determine the socially optimal level of intervention in education.

Other studies have tried to link school performance to the time of enrollment. For higher education, Dolton et al. (2003) described a production function where academic success, given by individual performance on the final exam, depends on the time spent at school. They show that the schooling time is four times less profitable than teaching in a working group. As a general form of intervention, they used public expenditure in education. Gupta and Verhoeven (2001) evaluated the effectiveness of public expenditures in 37 African countries over the period

1984-1995 and compared them with Asian and Western countries. They showed that on average, African countries are less efficient than Asian countries and countries in the Western hemisphere. Afonso et al. (2006) showed a clear distinction between countries according to indicators of absolute performance and cost effective type indicators. National structures for utility costs can play a crucial role and lead to situations where some systems offer public service and others do not. This may be due to allocation rules and routine border performance allowed by the technical frontier.

Kirjavainen and Loikkanen (1998) used a Tobit model powered by the levels of efficiency from Data Envelopment Analysis (hereafter DEA), to explain the determinants of efficiency of secondary schools in Finland. In their approach, the education of parents is a driving factor that determines the differences in school performance. Bradley et al. (2001) also used the DEA and Tobit model to evaluate the technical efficiency of English secondary schools. The average efficiency rate obtained were between 83% and 75%. The authors also found that competition between schools improves the efficiency level of schools. This finding is consistent the results of Waldo (2007) who studied the performance of Swedish secondary schools using DEA. In the case of Portugal, Oliveira and Santos (2005) examined institutional indicators. They were particularly interested in relaxing the convexity constraint. Simar (2003) found that the unemployment rate, access to health services, adult education and infrastructure endowments are determinants of academic performance. Rubenstein et al. (2007) used a sample of schools in the north-eastern USA and found that the effectiveness of policies is conditioned by structural elements including vocational training. This brief literature review outlines the ambiguity and difficulty of measuring the efficiency and performance of school. The school with superior performance can be the one that has better policy, but it can also be the one which is in a very favorable environment.

3 A Theory of interventions in education

In most countries, education is largely a national public service, whose organization and operation are provided by the government.[7] However, local administration can also be involved in the development of this public service. There are several stakeholders in the education sector, each with specific and complementary roles. At the national level, the *government* is competent in all aspects of pedagogy, curricula, national qualifications and management of teaching staff, etc. At the regional level, *local administrations* (counties, districts, municipalities, etc.) are in charge of the decentralized services of the ministry of education. The role of *communities* (e.g. association of parents) is also important. Indeed, parents are full members of the educational community. Through their representatives, they participate in school councils, class, and administration of the institutions which indirectly implies the application of education policy. It is worth to note that there often exist structures of consultation (which enable their opinion to guide decision-making or allow actors and partners of education to meet and take decisions) and sometimes technical committees dealing with issues of collective interest. Interventions by all these stakeholders in education have direct and indirect impact on pupils' performance.

However, these interventions are implemented in an environment with uncertainty which is related to the state of nature.[8] This environment may be favorable or unfavorable to the expected result of the intervention. For example, unforeseen constraints (e.g. stochastic shocks) on resource availability can lead policy makers to modify or discontinue the intervention. Similarly, unobservable individual factors related to the environment can make the same intervention more efficient for some individuals and less for some others. Sometimes, the results can go in the opposite direction due to interaction with other factors. This raises the question as to how uncertainty affects the impact of interventions in education. In what follows, we develop simple models that account for these situations and help us to better understand the economic mechanisms through which these interventions operate as well as their effects on well-being.

3.1 The benchmark model without uncertainty

Let X_t denote a vector whose n components are the criteria measuring agents' (pupils') performance (e.g., achievements like score, repetition rate, etc). All interventions are captured by the vector U_t with r components. The aim is to start with an initial state X_0 and reach an optimal state X_T, where pupils' performance is better, T being the final time for the effects of interventions. The equation of variation of pupils' performance ia:

$$\dot{X}_t = F(t, X_t, U_t). \tag{1}$$

The optimality means that in the final state, the interventions lead to a state close to their objectives. At the level of an agent, it does not mean that all performance indicators' at period T are higher than those in the initial period. But the average level achieved with X_T is expected to be higher than the one with X_0. We will consider two cases for Equation (1): the linear and the nonlinear.

3.1.a The linear case

We assume that F can be written in the form

$$\dot{X}_t = P(t)X_t + Q(t)U_t + R_t \tag{2}$$

where $P(t)$ and $Q(t)$ are matrices of respective order $n \times r$ and $n \times n$. Equation 2 shows that variations in performance are additive with respect to successive separable interventions. All things being equal, $P(t)$ represents the rate of growth performance in the absence of policy interventions with trend $R(t)$. Similarly, $Q(t)$ denotes the average change in performance following an intervention. We can assume different frameworks: i) independence of interventions and ii) existence of a centralized public target (as a global education policy overseen by the government, in the form of recommendations to stakeholders) that guides the interventions. Let us consider each of these frameworks in turn.

Proposition 1 *The interventions leading X_0 to X_T can be written as:*

$$U_t = B(t)c + v(t) \tag{3}$$

where $c = A(T)[Y^{-1}(T)X_T - \int_0^T Y^{-1}(\theta)R(\theta)\,d\theta]$ is a vector of constants, v is a function of time, $B(T) = Y^tQ(t)$ and $Y(t)$ denotes the fundamental matrix of the system $\dot{X}_t = P(t)X_t$.