Economic Modelling 49 (2015) 308–313

Contents lists available at ScienceDirect

Economic Modelling

journal homepage: www.elsevier.com/locate/ecmod

Economic growth and the harmful effects of student loan debt on biomedical research

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ARTICLE INFO

Article history:
Accepted 10 May 2015
Available online 30 May 2015

Keywords:
Biomedical research
Economic growth
Higher education cost
Student loan debt

ABSTRACT

Modern theories of economic growth emphasise the key role of human capital and technological progress in determining a society's standard of living. In some advanced countries, however, higher education costs and the level of indebtedness among graduates have increased dramatically during recent years. This phenomenon is particularly evident in the United States, and within the biomedical sciences sector. In this paper, we develop a basic model of economic growth in order to investigate the effects of biomedical graduate indebtedness on the allocation of human resources in R&D activities and hence on the growth process. In particular, we derive a 'science–growth curve', i.e., a relation between the share of pure researchers and the economy's rate of growth, and we find two possible effects of student indebtedness on economic growth: a composition effect and a productivity effect.

1. Introduction

Modern theories of economic growth emphasise the role of technological progress in determining a country's standard of living (Jones and Vollrath, 2013). Technological progress, in turn, is ultimately driven by new ideas, generated within research and development (R&D) activities (Weil, 2012). As improvements in knowledge depend heavily on the intellectual efforts of the human capital involved in R&D (NSB, National Science Board, 2012), both the endowment and the quality of pure and applied researchers are crucial factors in explaining differences in per capita income across countries and over time (Meek et al., 2009).

The influence of R&D on economic growth has become even more important over the past two decades, with the advance of so-called 'knowledge-based economies' (OECD, Organisation for Economic Co-operation and Development, 1996). One of the key pillars of economies based upon the production, distribution and use of knowledge is the 'biomedical sciences sector' — i.e., the complex system of interactions among higher education, scientific research, industrial production, and health care services. The role of biomedical sciences as an engine of economic growth is growing rapidly in both developed and developing countries (Bedroussian et al., 2011).

In some developed countries, however, education costs have increased dramatically in recent years. During this period the rate of growth of college tuition and fees has been, on average, substantially higher than that of the median family disposable income (Johnstone and Marcucci, 2010). This phenomenon is particularly evident in the United States (Callan, 2008), where graduate and postgraduate education is also usually financed by means of student loans (Lee, 2013). As a result, the level of indebtedness among U.S. students and graduates has been increasing sharply for years (Cochrane and Reed, 2012). Nowadays, the causes and consequences of rising student debt burdens are sources of concern for academics and policymakers (Gale et al., 2014; Li, 2013).

In particular, questions have been raised about the negative influence of this phenomenon on a variety of economic outcomes, such as education and career choices, household formation and homeownership, retirement savings decisions, entrepreneurship, and new business formation, among others (CFPB, Consumer Financial Protection Bureau, 2013). Although concerns about the potential harmful effects of increasing student indebtedness are widespread throughout U.S. colleges and universities, the problem seems to be especially troubling for medical schools (Fresne and Youngclaus, 2013; Jolly, 2005) and, more generally, for the actual and future situation of tuition and indebtedness within biomedical sciences as a whole (Garrison et al., 2005). In this paper, we develop a basic model of economic growth in order to investigate the effects of biomedical graduate indebtedness on the allocation of human resources in bio-based R&D activities and, as a result, on the process of economic growth.

The remainder of the paper is structured as follows. The next section briefly outlines the standard Romer endogenous growth model (Romer, 1990) and applies it to a simplified 'biomedical' knowledge-based

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http://dx.doi.org/10.1016/j.econmod.2015.05.004
0264-9993/

economy. Section 3 attempts to improve the model by introducing the difference between pure and applied research. Section 4 first illustrates the 'science–growth (SG) curve' — i.e., the relationship between the share of pure researchers and the economy's rate of growth — and, second, makes use of this basic tool to investigate some possible consequences on economic growth of increasing student debt burdens. The last section concludes with a few suggestions for further research on the long-run macroeconomic implications of student loan debt in the biomedical field.

2. Economic growth in a biomedical-based economy

The importance of human capital, both as a condition and as a consequence of economic growth, has been deeply investigated during recent decades (Mincer, 1984). In particular, the interest in education as a source of economic growth dates back to the early developments of Solow (1956)'s model (Denison, 1967; Nelson and Phelps, 1966). Since then, the analysis of the interactions between investments in human capital and economic growth has played a key role in a number of seminal contributions (see, e.g., Lucas, 1988; Barro, 1991; Mankiw et al., 1992) and has given rise to a large body of scholarly literature (Acemoglu, 2009).

Relative to this considerable amount of knowledge about the effects of human capital on economic growth, much less is known about the possible consequences of student loan debt on people's investment in human capital and employment decisions. What we know on these issues comes primarily from empirical investigations. In particular, there is evidence that debt tends to affect college major choice, driving students away from fields with lower expected wages (Rothstein and Rouse, 2011). Researchers also find a negative relationship between postgraduate education and student debt; that is, students with loan debt, ceteris paribus, seem to be less likely to apply to graduate school (Akers, 2013; Millett, 2003). Furthermore, in the labour market, high student debt appears to be the main impediment against a career in the public or not-for-profit sectors, where wages are typically lower than those in business sectors (Field, 2009; Rothstein and Rouse, 2011).

So far, however, there has been little attention on the influence of student loan debt on economic growth. In particular, to our knowledge, there is a lack of theoretical grounding. This paper should be considered as an introductory attempt to fill this gap. We aim to develop a simple but coherent model in order to investigate the possible harmful effects of the burden of student debt on long-run macroeconomic performance, focusing in particular on the biomedical sciences sector.

2.1. Romer's approach

Let us consider a simple knowledge-based economy in which goods and new ideas are the result of production processes that combine knowledge and highly skilled labour. In this economy, there are two sectors: a consumption goods sector that produces output and an R&D sector that produces new knowledge.[1]

Specifically, at each point in time, output (Y_t) is produced by using knowledge and labour, according to the following aggregate production function:

$$Y_t = A_t \times L_{Yt} \tag{1}$$

where A_t denotes the stock of existing ideas and L_{Yt} is the number of workers (for example, physicians). Because ideas are nonrivalrous, the stock of existing knowledge is also used in the R&D sector, together with biomedical researchers (L_{At}), in order to produce new ideas, according to the following aggregate production function:

$$\Delta A_t = z \times A_t \times L_{At} \tag{2}$$

where Δ is the 'change over time' operator, so that ΔA_t measures the flow of new knowledge produced during period t (i.e., $\Delta A_t = A_{t+1} - A_t$), and z is a parameter that denotes labour productivity (that is, the average number of new ideas generated per researcher). In contrast to ideas, labour is rivalrous: although the available stock of high skilled workers (L) can be freely allocated to either of the two sectors, the same worker cannot simultaneously be allocated to both (output and research) sectors. Therefore, the economy is subject to the following resource constraint: $L_{Yt} + L_{At} = L$ (where L is also equal to the total population, which we consider to be constant).

In this simplified biomedical-based economy, researchers produce new ideas and physicians produce health care (such as diagnoses, medical treatments and disease prevention). To begin, we assume that researchers are a constant fraction (q) of the total labour force, so that $q \times L = L_{At}$. This leaves the economy with $(1 - q) \times L = L_{Yt}$ workers allocated to the consumption goods sector. As a result, the production functions for output and ideas become, respectively:

$$Y_t = A_t \times (1 - q) \times L \tag{3}$$

$$\Delta A_t = z \times A_t \times q \times L. \tag{4}$$

This means that, for a given sectoral allocation of the labour force, workers in the goods sector produce an amount of output per capita that depends on the stock of existing knowledge. Dividing the new production function for the output sector — i.e., Eq. (3) — by total population (L) gives:

$$Y_t/L = [A_t \times (1 - q) \times L]/L \rightarrow y_t = A_t \times (1 - q) \tag{5}$$

where, given q, the average level of output per person ($Y_t/L = y_t$) is proportional to A_t. More specifically, output per capita increases with the flow of new ideas invented by the people involved in the research activity, but because the number of researchers is constant, Eq. (5) also shows that:

$$g_y = g_A + g_{(1-q)} \quad \rightarrow \quad g_y = g_A. \tag{6}$$

The rate of growth in output per capita (g_y) will be approximately equal to the rate at which researchers generate new ideas, g_A. Finally, Eq. (4) indicates that, over time, the accumulation of new ideas proceeds at a rate equal to:

$$\Delta A_t/A_t = (z \times A_t \times q \times L)/A_t \quad \rightarrow \quad g_A = z \times q \times L \tag{7}$$

that is, the growth rate of knowledge is constant and exogenously determined by the parameters z, q and L. However, since $g_y = g_A$, the rate of growth in output per capita ($\Delta y_t / y_t = g_y$) is also constant and equal to the product zqL. In other words, economic growth is driven by technological progress resulting from R&D.

3. Pure and applied biomedical research

In economics and science policy, it is often useful to distinguish between basic and applied research (Roll-Hansen, 2009). We introduce this distinction in the model by assuming that the R&D sector includes two main activities. The first is a curiosity-driven research process, undertaken primarily to acquire new knowledge of general interest, without regard to particular applications. The second is a practical-driven

[1] For the sake of simplicity, following Jones (2011) and Weil (2012), we focus only on the basic elements of Romer (1990)'s model. We therefore present the model in a simplified version, without discussing its microeconomic foundations.