INDIVIDUAL DECISION FOR A SCIENCE EDUCATION:

Path for growth

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Introduction and Background

While appropriate allocation of resources can maximize a nation's output, technology is the essential component that promotes growth beyond the boundaries set by resources. Through the improvement of available equipment and knowledge, individuals can significantly enhance productivity and thus increase the economic output. In the basic economic framework of the Cobb-Douglas production function, technology can augment the total factor productivity. Furthermore, beyond the increased output given the same set of resources, publically available technology can also provide external effects in individuals' lives, enhancing the average living standards of individuals.

From this framework, investing in technological development becomes a necessity to avoid stagnating growth. However, technology is the product of scientific activity. Even though there is a significant time gap between basic research and the eventual resultant technological improvements, research efforts are essential to new discoveries. This delay be-

tween the knowledge acquisition and product development, however, can have an effect on the efficient level of investment in science, illustrating how the field is susceptible to market failure. In a study done by Martin and Scott, the nature of innovation was also taken into account, and the study concluded that, even in the industrial sector, individuals do not always choose an efficient level of investment in research and development; as a consequence, it is important to create "a long-term institutional framework for the support of basic research, generic-enabling research, and commercialization" (Martin and Scott, 2000). Influence from the government thus becomes important in order to achieve social efficiency.

Research endeavors, however, are highly dependent on the human capital of those conducting them. The knowledge base required to tackle contemporary problems continuously increases as human beings improve their understanding of nature and society. Thus, as we advance our knowledge, new generations of researchers must learn an increasing basis of background material to start contributing significantly to any field. This knowledge basis that will constitute the future human capital of the individual is obtained in the educational system.

A solid educational system thus forms the essential source of future researchers. However, most individuals do not choose to follow a research career: according to statistics by UNESCO, the United States, which has been a leader in research and development, only has 4,673 researchers per million inhabitants, which corresponds to a little less than 0.47% of the population, with total R&D expenditure being 2.9% of GDP (UNESCO, 2010).

To understand the reasoning behind the numbers, and find potential pathways for improvements in higher education and consequentially scientific research, this article will analyze the individual decision given the options in the current system. By analyzing the educational complex and the returns of education for individuals, we will try to explain the behavior of individuals that lead to higher education and engagement in research initiatives.

Microeconomic Analysis of individual decision making for higher education

Rational individuals would decide to pursue higher education if they can increase their net benefit, that is, if the marginal benefit the degree to be obtained exceeds marginal costs. In general, one may think of the increased income due to higher productivity and specialization as the main utility gains for the individual, while the cost would be the tuition costs associated with a college degree. However, most individuals must also forgo potential income that could be earned during the educational period. In addition, the benefits side is also not so trivial: positions that require higher levels of education also involve different work requirements, and given that an individual had a choice in his or her area of specialization, their future work would be considered more enjoyable than other areas.

This analysis is more fitting for tertiary education, since it is not offered as a public good and is not compulsory at any level. Two different approaches have been previously developed in the study of the demand for education, the longitudinal and transversal approach (Correa, 1995). In the former, any individual would choose to increase the length of their educational period as long as the additional income gained is still greater than the loss in income due to the smaller time spent in work. The transversal approach differs in that the individual's time is divided into many more pieces, each of which can be dedicated to learning or employment; while the mathematical description is more complex, the results show that the order in which education comes has a large influence on total income (Correa, 1995)

However, many other factors can also influence the pursuit of tertiary education. The high tuition costs often form an effective barrier for this type of investment, and impedes the entry of many potential students. Thus, even if one considers that entering a higher education program would result in greater net well being, the lack of sufficient funds to commit to

this decision would not allow the individual to complete the investment. Because of income inequality, federal aid programs then become relevant. However, the loan process can complicate the economic analysis of the situation. While the potential gains with increased income from higher education can offset the total cost of borrowing, it is not completely clear that all individuals will be successful. In many circumstances, the quality of the education also becomes relevant in the student's future employment process. As a result, those who are risk averse could still choose not to take the loans options, if they are offered this possibility.

From the individual's private perspective, tertiary or higher education is thus mainly a competition between the prospects of future income, and the costs associated with receiving this education, comprised of direct costs and forgone income. While student loans can facilitate entry for those without sufficient funds in an attempt to distribute education more uniformly across different income classes, the analysis is much more complex. Analysis of student loans have shown that certain groups are more likely to default than others, which still shows that the system is not completely efficient in providing equal education opportunities for all (Dynarski, 1994).

The situation becomes even more complex due to external effects of education. Evidence of the social benefits of education have been extensively analyzed, and signal that social returns from increased educational attainment are generally higher than private benefits. Moretti's analysis on social returns, for example, shows that even in terms of productivity, individuals only receive a portion of the benefits from their own education and a "significant part accrues to others" not only in high tech industries that demand a highly specialized labor force, but across multiple sectors (Moretti, 1998). Beyond increased productivity, education can also have beneficial effects on society in general. Blundell et. al. point out not only that education increases "social cohesion" but also that overall higher levels of education can generate external effects on productivity (Blundell et. al. 1999). Backman and Bjerke

(2009) also emphasize the effect of "knowledge spillover" which once again gives evidence that complicates the marginal analysis, due to greater social returns of education.

Due to the social gains of education, which provide no direct remuneration for the individual investment in higher education, public investments in education become essential to achieve greater efficiency in the human capital of a nation's population. Thus, just as companies would choose to underproduce without the prospect of commercialization and profit from the external effects of their production, individuals would not take these external effects into account when pursuing higher education. As a consequence, there is a natural tendency for individuals to underinvest in education.

In addition, the relatively high costs of education create a tendency that increases the economic disparity between social groups. If lower income individuals cannot afford to stop earning income, most would not be able to enroll in universities and thus have a smaller earning potential than those who already have funds. Instead of functioning as a tool to promote equality, higher education could become an opportunity reserved mostly for those with already higher relative household income. While loans can be used to pay for direct costs, these do not necessarily sustain an individual's family. Thus, the complexity of higher education calls for policy measures that provide incentives for a more equitable access as well as socially efficient levels of investment.

The availability of public education has been able to push most individuals to complete high school: according to the Bureau of Labor Statistics, the unemployment rate for those without a high school diploma is almost 4% higher than for those with only a high school diploma, and almost twice the average rate. In addition the median earnings of those with no more than a high school diploma compared to those who have not graduated high school is already 38.4% higher (Bureau of Labor Statistics, 2012). However, the costs associated with tertiary education, despite the incentives for higher returns has impeded similar results, with only slightly over 30% of the pop-

ulation age 25 or older who have obtained a bachelor's degree or higher, while close to 90% have a high school diploma (Ryan & Siebens, 2009).

Quality as tool

Data indicate that the public educational system has been effective in increasing the educational attainment of the population. However, the quality of primary and secondary education is also relevant; according to Jamison et. al (2007), estimates show that increasing education quality by one standard deviation (as measured by test scores) could cause annual per capita income growth of 0.5 to 0.9%; furthermore, the quality of education was also shown to be inversely related to infant mortality rates. Thus, while public education does provide better opportunities for individuals of various income levels, the variation in the quality of education is also a relevant factor. Improving the quality of the public educational system could thus provide support for increased participation in tertiary education.

This relationship between primary and secondary education performance and enrollment in universities can provide an alternative means of improving attainment for less privileged individuals without removing tuition fees. Tuition can provide funding for the development and improvement of university services and facilities, which can help establish better quality for university teaching and research. However, it still provides an obstacle for many individuals, and can adversely drive their behavior, since many could not value the education enough to accept loans. As was previously mentioned, higher education has significant social effects, which results in many difficult to measure benefits. This means that policy measures should aim to expand access and encourage higher levels of education.

If the tuition system cannot be directly removed while still maintaining school quality throughout the system, improving

the quality of the available public education could provide a step towards better access. In addition, the overall knowledge gains would disperse towards gains in human capital and overall increases in productivity and output. However, it is important to support public schools, which have signaled poorer performance, which are typically located in low-income areas. Since these already receive smaller local tax contribution, they would typically have fewer funds to provide students with quality education. This would in turn affect the future decisions of the students on whether to continue their education. In addition, the below average quality of the schools would augment the low-income difficulties that hinder many families from sending recent graduates to college.

In addition to improving the public education system for all income levels, it is also important to provide a concrete system to finance tertiary education for low-income households. According to McPherson and Schapiro (1991) the total cost of higher education has a large negative effect for students who originate from low-income households. However, higher income individuals are not as adversely affected by the increasing costs of education. This evidence indicates that while the total benefits could significantly offset the additional costs of higher education, the barrier instituted by high tuition costs prevents poorer students from making the initial investment. Other studies, which analyze data from the 1970s (Hansen, 1983), have suggested that student aid programs must be precisely targeted and sufficiently funded to have a significant effect.

Policy alternatives to the traditional student loans could therefore improve access to tertiary education, and thus promote greater growth as well as a higher supply of science and technology researchers. Targeting access and quality thus becomes crucial in the formulation of a scientific basis for future generations. The analysis thus demonstrates that targeting primary and secondary education quality, as well as improving prospects for low-income families for tertiary education could significantly enhance overall productivity. In addition,

spillover effects of this type of government investment include potential improvement of overall well being.

Decision to pursue science

This marginal analysis, however, can also be extended in the selection of the field of specialization, as well as future employment goals. In this case, however, the benefits are not restricted to income, but also include satisfaction with one's employment conditions and interests. Nonetheless, altering the basic forms of incentives (such as future income prospects) can still affect individual choice. Thus, the analysis becomes more complex, as students must often choose a career path before their actual entrance into the labor market. This requires the interpretation of current trends in any field and the future of typical values for income and employee demand.

Individuals must then balance the costs and gains from their choice by taking into account predictions of what the future of any specific field's labor market will look like. If they do not believe employment opportunities will offset the cost of their education, most would likely avoid the risk and find an area where potential income (accounting for the uncertainty of employment in any area) is higher, especially if it requires the risk of taking student loans.

Preferences and interests can, however, complicate the analysis. According to Behman et. al. (1998) the individual abilities of students are also a factor in how job market dynamics affects the supply of labor in that field. One example given in the study provides two possible scenarios: in the first, students with "a real passion for the subject" would continue in the field. Such students have "relative advantages" when compared to students with lower affinity for the field, and therefore the quality density for entering employees would increase. Alternatively, one can also consider a saturation in which the higher quality students can more easily transition into another field and continue their above average performance. In this

case, the quality of entering employees would decrease due to the smaller wages or higher unemployment.

The second scenario would technically fit the large-scale equilibrium condition where employers pay according to the marginal revenue product that each employee provides. If the quality decreases, they might be less productive which would signal a decline in income. However, the situation is not so simple, especially in fields that require high levels of education. Furthermore, if we focus our analysis on research, quantifying the real returns to a scientist becomes even more difficult. Since breakthroughs often take a long time to reach marketable technologies, one cannot base scientific investment on the traditional economic analysis. Furthermore, most of the researchers are not directly compensated if their basic research eventually becomes commercialized. Many products, while clearly the product of new discoveries in science, cannot often be traced back to a single or small number of research publications in any field. Consequentially, the salary for scientific careers is normally established through other techniques. While individual productivity in the form of research output can still be taken into account, industrial profit would not directly affect basic research remuneration.

The above analysis implies that potential income is not necessarily the single most important benefit for career choice that requires a high level of education (especially those with graduate level degrees). If the high quality students, who, according to the reference cited above, possess significant interest in the field, would not leave given a certain change in salary, they most likely value the interest they have in their work above small fluctuations in income. In addition, it could also mean that highly motivated individuals, due to the quality of their work, would be those obtaining the limited supply of positions, which forces others into alternative fields. This, however, also signals that the remuneration for research positions could be below efficient level, since highly interested individuals view the knowledge pursuit as a large portion of their benefit from being employed in academic careers.

As a consequence of the depicted scenarios, there would generally be a minimum number of individuals who would still pursue scientific research for their interests, despite low levels of investment. However, this value would not be socially efficient. Since the outcomes of science become apparent only after a finite time gap, underinvestment in the field could affect future growth and technology development. Ultimately, it is important to provide incentives for the pursuit of science careers by attracting more students.

Thus, policy can tackle both sides of the situation: increasing benefits, through greater investments in basic research and technology development, would provide individuals with relatively improved employment prospects, through greater funding and opening of positions. Alternatively, decreasing the costs of education after public schooling could also provide incentives for individuals to pursue their interests. In addition, the private sector could also be a source of research investments even at the basic level, due to the eventual spillovers associated with scientific advancement. Ultimately, genuine interests in various careers paths can be stimulated through quality education and incentives at the primary and secondary public schooling level. However, for most individuals, significant interests are a necessary but not sufficient condition for the decision to obtain higher levels of education and pursue a specialized career. This can be accomplished by improving the employment prospects in the field through larger investments in science and increased funding opportunities, as well as the decreased cost or risk associated with education.

Conclusion

Since researchers must go through high levels of schooling, access to quality education becomes highly relevant. In addition, it is important to provide sufficient incentives to attract individuals to research and development fields. This is most ef-

fectively done through a quality education system, as well as job prospects. Individuals must not only value the potential work, but also be provided with enough security for employment prospects and income.

Although investments in science do not have an immediate effect, they are essential for continued growth. In addition, the knowledge gain has large positive externalities not only in social well-being, but also in future technology creation, which can generate new industries and have dynamical effects on the economy.

While college tuition does provide a barrier to higher education for specific households, it is important to address other issues that can lower the effective costs for individuals. This includes instituting a loan system that encourages students to pursue careers in high demand fields, as well as improving the quality of primary and secondary education.

Ultimately, education provides benefits not only for the individual but also for society as a whole. The large external effects call for investments on all levels; nevertheless, certain areas must receive greater attention for long term development, since student choices receive great influence from the prospective labor market.

REFERENCES

Backman, Mikaela, & Bjerk, Lina. (2009). Returns to higher education—a regional perspective. The Royal Institute of technology. Centre of Excellence for Science and Innovation Studies (CESIS). Jönköping International Business School. Retrieved from http://papers.cesis.se/CESISWP171.pdf

Behrman, Jere R., Kletzer, Lori G., McPherson, Michael S. and Schapiro, Morton Owen. (1998). The microeconomics of college choice, careers, and wages: Measuring the impact of higher education. Department of Economics Working Paper No. 423. doi: http://ssrn.com/abstract=142108 or http://dx.doi.org/10.2139/ssrn.142108

Blundell, Richard, Dearden, Lorraine, Meghir, Costas, & Sianesi, Barbara. (1999). Human capital investment: The returns from education and training to the individual, the firm and the economy. Fiscal Studies, 20(1), 1–23. doi: 10.1111/j.1475-5890.1999.tb00001.

Bureau of Labor Statistics, (2012). Education pays. Retrieved from Bureau of Labor Statistics, Current Population Survey website: http://www.bls.gov/emp/ep_chart_001.htm

Correa, Hector. (1995). The microeconomic theory of education. International Journal of Educational Research, 23(5), 405–472. doi: http://dx.doi.org/10.1016/0883-0355(95)00014-3

Dynarski, Mark. (1994). Who defaults on student loans? Findings from the national postsecondary student aid study. Economics of Education Review, 13(1), 55–68. doi: http://dx.doi.org/10.1016/0272-7757(94)90023-X

Hansen, W. Lee. (1983). Impact of student financial aid on access. Proceedings of the Academy of Political Science, 35(2), 84–96. doi: 10.2307/3700892

Jamison, Eliot A., Jamison, Dean T., & Hanushek, Eric A. (2007). The effects of education quality on income growth and mortality decline. Economics of Education Review, 26(6), 771–788. doi: http://dx.doi.org/10.1016/j.econedurev.2007.07.001

Martin, Stephen, & Scott, John T. (2000). The nature of innovation market failure and the design of public support for private innovation. Research Policy, 29(4,Äì5), 437–447. doi: http://dx.doi.org/10.1016/S0048-7333(99)00084-0

McPherson, Michael S., & Morton Owen, Schapiro. (1991). Does student aid affect college enrollment? New evidence on a persistent controversy. The American Economic Review, 81(1), 309–318. doi: 10.2307/2006804

Moretti, Enrico. (1998). Social returns to education and human capital externalities: Evidence from cities. From http://darp.lse.ac.uk/PapersDB/Moretti_(98).pdf

Ryan, C., & Siebens, J. U.S. Department of Commerce, Economics and Statistics Administration. (2009).Educational attainment in the united states: 2009. Retrieved from United States Census Bureau website: http://www.census.gov/prod/2012pubs/p20-566.pdf

UNESCO. (2010). Unesco institute for statistics. Retrieved 02/17, 2013, from http://stats.uis.unesco.org/unesco/TableViewer/document.aspx?ReportId=124&IF_Language=eng&BR_Country=8400&BR_Region=40500