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Draft Paper

A Network Model of Education:

Network Effects and Externalities

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1. Introduction

The role of government intervention in education remains a hotly debated topic especially in the context of developing countries. Much of the argument revolves around whether substantial positive externalities exist in the consumption of education by individuals. If social rates of return to education are significantly higher than private rates of return, government intervention is more likely to be warranted. This paper will review existing literature on the social rates of return to education and critically examine the arguments for the presence of positive externalities in education.

While most agree that education is an important contributing factor towards economic development, there is widespread disagreement over the centrality of its role. Some believe that education is of paramount importance, that it is a necessary precondition to economic growth and the primary driver for the development process. On the other hand, there are suggestions that education is not a precondition but is instead a natural result of economic growth, implying that governments should spend their energies on other more important development assistance programmes. The question as to the existence of positive externalities in education needs to be answered before this issue can be resolved.

Part of the difficulty in understanding the role of education in economic development is the fact that education is a multi-faceted good that has characteristics of private as well as social public goods. While it is easy to see that there are significant private benefits to the individual in the consumption of education, conventional wisdom suggests that there are social benefits to universal and subsidized provision of education, especially primary or secondary level education in developing economies. Any discussion of education as a public good cannot avoid the attempt to disentangle the private benefits from the public effects of education.

This paper will attempt something new, borrowing concepts from the literature of network economics, in order to better conceptualise education as a social public good. Network economics has its roots in the study of transport and telecommunication networks, both of which like education are goods

that were once thought of as pure public goods, but have in recent times been considered more as private goods. The modern economy will be very much diminished without the transport, telecommunications, and information networks that are central to the process of economic and technological development. Education is similarly central to the process of economic development, even while there is debate over its status as a social public good or a private good.

2. Private and Social Rates of Return to Education

According to Schultz (1988), the expansion of public education systems worldwide has provided the average child in every country in the world with increased years of schooling during the period 1960 to 1983. The gap between high and low income countries in educational opportunities has narrowed both relatively and absolutely. In addition, the wide gap between the educational attainment of women and men has narrowed on average. The income elasticity of public expenditures on primary and secondary education is 1.4 and 1.5 respectively. Despite all this, there has been a widening in the income gaps between the richest and the poorest countries. This has sparked renewed interest in measuring the rates of return to education, especially in the context of distinguishing private from social returns to education.

Estimates of the returns to investment to education have been carried out since the 1950s (Psacharopoulos, 2002). Most existing studies on rates of return to education are focused on private rates of return, even as the claim that education provides social returns above private benefits remains hotly debated. Empirical studies of private rates of return to education typically use the incomes of individuals with different educational endowments as a measure of the rate of return, employing various econometric techniques including instrumental variables in order to control for the relationships between education and unobserved individual characteristics that both affect income. Schultz (1988) mentions private rates of return between 10% and 40%. As for social rates of return to education, there are a number of approaches in estimation. Most of these revolve around using instrumental variables to identify the effect of average education levels of a particular geographical area separately from the effects of individual

education. The range of estimates varies widely and there is as yet no consensus as to whether there are in fact positive social returns to education.

Venniker (2000) discusses different externalities that may account for a gap between private and social returns to education, as well as empirical evidence for their relevance. He identifies three types of externalities: those related to the effect of human capital on current productivity (static externalities), those related to the effect on learning and on technological change (dynamic externalities), and others that are related to non-pecuniary effects of human capital. The primary static human capital externality is that an individual's human capital enhances the productivity of other factors of production like physical capital and the human capital of others, through channels that are not internalized by individual families or firms (Lucas, 1988). The second type of dynamic externalities are generated when creating and adopting new technology is less costly with higher average levels of human capital, and when future creation of human capital is dependant on prior levels of human capital. These cost savings are not internalized by market participants due to market imperfections such as coordination failures. Other non-pecuniary human capital externalities have been identified by Haveman and Wolfe (1984), and include improvements in intra-family productivity, childcare, family healthcare, and reductions in teenage pregnancy, crime rate, increased social cohesion and charitable giving.

Psacharopoulos (2002) in ongoing research at the World Bank finds that the classic pattern of falling returns to education by level of economic development and level of education are maintained in the latest data. Overall, the average private rate of return to another year of schooling is 10%. Average returns to schooling are highest in the Latin America and the Caribbean region and for the Sub-Saharan Africa region. Returns to schooling for Asia are at about the world average. The returns are lower in the high-income countries of the OECD. Interestingly, average returns to schooling are lowest for the non-OECD European, Middle East and North African group of countries. Overall, women receive higher returns to their schooling investments.

As for the social rates of return to education, Rauch (1993) using 1980 US data estimates a 2.8% rate of return to one additional year of education attributable to average educational levels (social returns) compared to 4.8% rate of return attributable to individual education (private returns). However, Acemoglu and Angrist (1999) using US data and using instruments for average schooling in 1960-80 generate statistically insignificant social return estimates ranging from -1% to less than 2%. Also, Psacharopoulos (2002) cites a few studies in Africa that have focused on estimating external benefits of education in agriculture using the education of neighboring farmers, which is analogous to the city based studies carried out by Rauch (1993) and Acemoglu and Angrist (1999). A one year rise in the average primary schooling of neighboring farmers is associated with a 4.3% rise in output compared to a 2.8% effect of own farmer primary education in Uganda (Appleton and Balihuta, 1996, reported in Appleton 2000). Another study finds 56% and 2% figures for Ethiopia, but Psacharopoulos (2002) commented that the estimate seems rather too high (Weir, 1999, reported in Appleton, 2000).

The results overall are unfortunately inconclusive although it appears that the ratio of social to private rates of return to education are higher in the developing world than in the developed world. However, more work is being done. Innovative rate of return studies are currently being used to both set overall policy guidelines and to evaluate specific programs. Examples include the Indonesia school building program (Duflo 2001) and Ethiopia's major sector investment program (World Bank 1998).

3. Introduction to Network Economics

The network economics literature is involved with the discussion of both *communication networks* and *"hardware-software" systems.* These two paradigms share many common results and are both relevant to the discussion of education. In the first case, the function of a *communication network* is primarily to provide connection services between people, locations or devices; so that they can gain access or to communicate with other people, locations or devices on the network. Classic examples of *communication networks* include the rail or telephone system.

A *communication network* is composed of *links* and *nodes* and its main function is to connect the *nodes* to each other via *links* (Economides, 1996). For example, in Figure 1 below, the *nodes* of a railway network are the train stations and the *links* are the train lines, the *nodes* of the air network are the airports and the *links* are the air routes.

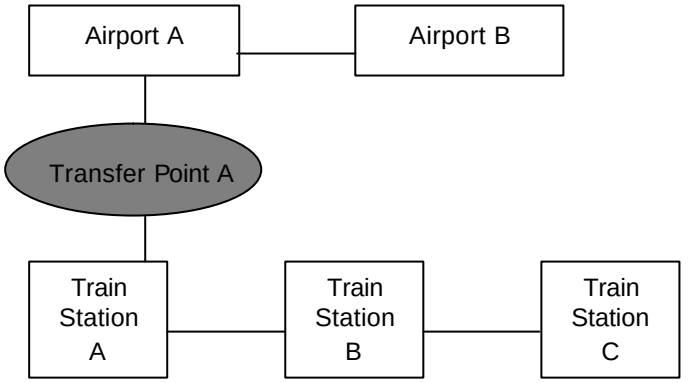

Figure 1

Separate networks are *inter-connected* to each other through the use of an *adapter.* In the context of a transport network, such an *adapter* is normally called a transfer point. The degree of *compatibility* between the two different networks depends on the *functionality* and *cost* of the *adapter*. For example, in the context of this transport network, one could ask if a passenger has to buy a separate fare for air and rail travel, or if baggage is automatically transferred at the transfer point, who pays for the adapter, and so on.

Networks are not limited to physical ones and can refer to metaphorical networks such as the networks of the speakers and the media of different languages. Figure 2 below illustrates a simple model of a "world" with only 2 languages. The discussion of different languages is close to the issue of education and has applications in modeling the choices of language of instruction and different education systems. It is used here as an illustrative example because of its simplicity and clarity.

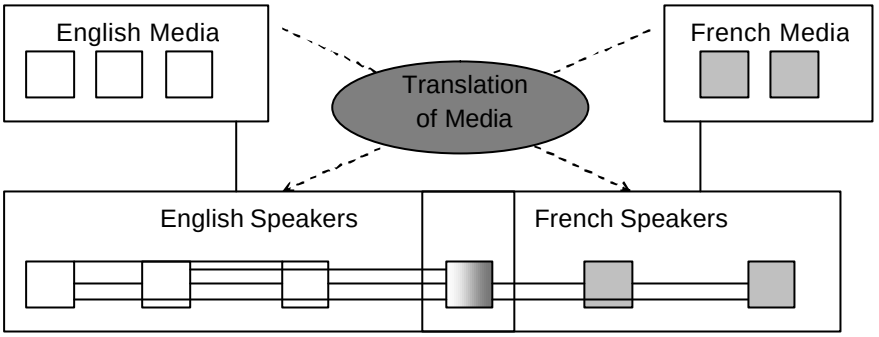

Figure 2

The shaded rectangles represent *groups* that contain multiple *nodes* that are represented by the smaller square boxes. In this simple model, there are 3 English media products, 2 French media products, 3 English-only speakers, 2 French-only speakers, and 1 bilingual speaker. Arrows between groups link each and every node within the group. Therefore, all media in a particular language is accessible by all speakers of that language. Note however, that some of the *links* are one-way; indicating the direction of access, i.e., media is accessed by language speakers, but media does not access anything (since it is simply a resource). The dotted lines indicate that not all of the individual *nodes* within the *group* are connected along that *link*, i.e., not all media products are translated. Translation is an *adapter* and may come at a cost. Speakers of a particular language can communicate with (i.e. *access*) all other speakers of the same language but cannot communicate with speakers of the other language. The bilingual person can communicate with everyone.

The number of people speaking each language is determined by the cost of learning the language, the budget constraint of each consumer, and the benefit of learning the language which is an increasing function of the number of connections the language provides and the value of those connections. These factors result in a distribution of reservation prices of the consumers which form the aggregate demand schedule for the network good.

Assume the following arbitrary parameters for illustrative purposes:

- The cost of learning English is the same as for French = 3.

- The quality of French media is the same as that for English media. Therefore, the value of connecting to each unit of media = 1. This assumes constant returns which is true at low levels of consumption. At high levels of consumption, there are diminishing returns to connections because an individual will become saturated with choices.
- There is no translation of media.
- The value of an interpersonal connection = 1. The constant returns assumption is also imposed here and it is noted that diminishing returns is likely to happen once an individual is saturated with more interpersonal connections that he can ever benefit from.
- The budget constraint for a new individual who is contemplating joining a network is 3.

The benefit of learning English is 7-3=4, and the benefit of learning French is 5-3 = 2. He will therefore choose English. Becoming bilingual is beyond his budget. The value of joining the network of English speakers has now increased to 8 from 7 due to the introduction of the new member. If demand is based on a range of consumers with different reservation prices, the demand for a network product will increase with the number of consumers using the product. This is referred to as network effects, which has been described as demand side economies of scale by Weitzel (2000). In the example above, the network effects are *direct* because the increasing value of the network is directly due to the increase in the number of users (since users connect with each other).

The supply for media products in a particular language can be defined as exogenous, or set to be dependent on the potential demand, which is the market size. If the latter is true, then the supply of media products is dependant on the number of users on the network. In this case, there will be an *indirect* network effect in addition to the *direct* network effect mentioned above. In equilibrium, the selection of media products in English must exceed that for French if both media product markets are monopolistically competitive with free entry and exit. Furthermore, if there are economies of scale in media production, then the larger English market will always be more efficient.

Katz and Shapiro (1994) note that due to the presence of network effects, such markets are prone to *tipping*, which is the tendency for one system to pull away from its competitors once it has gained an initial edge. Consumer heterogeneity and product differentiation limit the effects of *tipping.* If the perceived value of connections in a smaller network is higher than that for a higher network, it will counter the *tipping* effects of network size.

Note also that the *adapters* can improve the value of a network. If we assume that all English media is translated to French at no cost but no French media is translated to English, then the value of studying French to the original consumer that we considered is 8-3 = 5, while the benefit of studying English remains at 4. He will have chosen to study French instead of English.

4. Modelling Education as a Network Good

The model in Figure 3 below is a simple set-up involving the networks of people who are educated up to the primary level, people who are educated up to the secondary level, and the occupations requiring the respective educational levels.

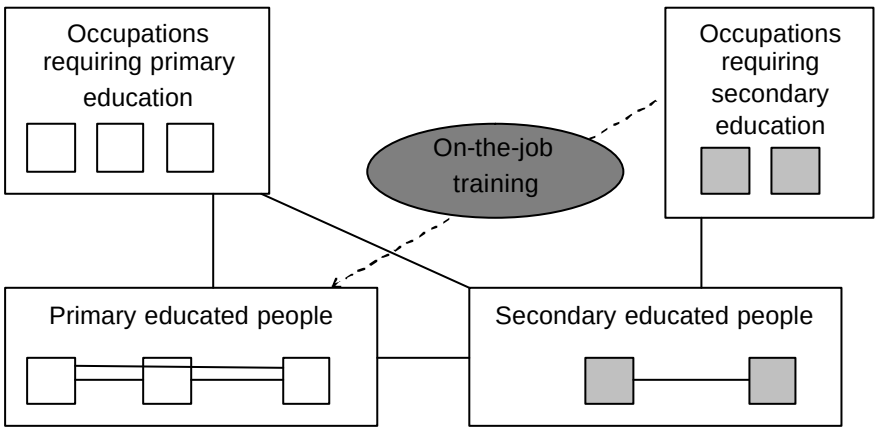

Figure 3

For simplicity of illustration, there are only 2 educational levels. The network can be described in much greater richness if parameters such as language of instruction and field of study are modeled as

groups together with relevant translation or cross-training *adapters*. The classification of educational levels can also be extended and a more detailed breakdown of educational achievements can be modeled.

There are 3 primary-educated persons, 2 secondary educated persons, 3 occupations requiring primary education, and 2 occupations requiring secondary education. On-the-job training, if provided by firms, may substitute for education in enabling access to occupations. In this model, "occupations" could refer to broad classifications of occupations or career opportunities including self-employment options. The same occupation (e.g. farmer) could even appear in more than one *group* in different forms if the way in which the work is performed changes with the level of education (e.g. low-tech farming vs. high-tech farming). A reasonable proxy for occupations from a data perspective will be the industries (of significant enough size) that require people of that specific educational background. The number of occupations should reflect the range of options that a person who obtains a certain educational qualification has access to, as increases in this number will be the source of any *indirect* network effects. The number of occupations available should be an increasing function of the number of people who have that particular required educational level, and will reflect the investment decisions of firms with regards to the type of operation and level of technology to engage in.

The actual number of occupations available within each occupation, and the wage rate of each occupation are assumed to be determined through competitive labour markets, and are therefore not endogenous variables in the model. The value of each *link* may but not necessarily be derived from average wage rates of all the occupations in the *group* since what is being modelled here is the non-marketed benefit of an additional *link*, not the marketed value of the job as measured by the wage rates. This value should be modelled with diminishing returns in increasing numbers of *links* and could have different functions for the different educational requirement *groups*. The average wage rate will be used separately to quantify the private marketed benefits of education.

The benefit of additional education also increases with the number of people who have that level of education since "interpersonal" *links* provide value as depicted in the model. As with the benefits accruing to the *links* to occupations, this value also should be modelled with diminishing returns in increasing numbers of *links* and could have different functions for the different educational *groups* reflecting higher values for *access* to more educated people. The "interpersonal" *links* between people represents a benefit that accrues through informal networking or simply the increase in the overall level of education. This could include knowledge spill-over benefits where the existence of more educated people in the community leads to an increased sharing of knowledge and knowledge transfer, or benefits relating to career or other opportunities that may arise due to such networking. This may include dynamic or static human capital externalities mentioned by Venniker (2000), where the average stock of human capital increases the productivity of others, or raises the future rates of human capital accumulation. The model here goes further by explicitly modelling these externalities as network effects. The third type of externality, the other non-pecuniary externalities mentioned in Haveman and Wolfe (1984) such as reduced crime rate and improved health may also be included in the benefits accruing to these *links*.

On a cautionary note, depending on the geographical scope of the definition of the *groups* of people by educational qualifications, this value may inadvertently capture agglomeration economies that are due to the concentration rather than the number of *links*. Adjustment for agglomeration economies due to concentration may thus be required.

Within this paradigm, education has been considered a *communication network* because it provides individuals with the ability to access job or career opportunities, or benefits through communication or linkages with other people with similar education. It can therefore be perceived of as a type of social or information infrastructure that facilitates communication and search.

Schultz (1988) describes two alternative explanations for the schooling-wage relationship. The human capital hypothesis, which has been the main focus of empirical studies of the rates of return to

education, focuses on education as a means of improving the ability and productivity of an individual. The alternative is a signalling or screening hypothesis where education does not improve the productivity of a worker but instead functions as a means for filtering or screening workers based on their native abilities.

The model above is consistent with both the signalling or screening hypothesis as well as the human capital hypothesis. The human capital approach is taken into account since education works in the model through the process of enabling individuals to function in superior occupations that require a higher level of education. Dynamic or static human capital externalities are taken into account through modelling them as network effects accruing from increasing levels of education through more valuable *links*. The signalling or screening hypothesis is taken into account because education in the model does not only enable individuals to function in occupations by increasing their productivity; it also performs the function of linking individuals to these occupations at the same time. In the construct of the model, the effect of enabling through ability enhancement and the process of linking through search, signalling or screening are closely intertwined, providing a holistic approach encompassing both of these hypotheses.

5. Network Effects vs. Network Externalities

The model as it stands does not necessarily imply the existence of network externalities. Liebowitz and Margolis (1994) warn against the quick conclusion of network externalities in the presence of network effects. While network effects may indeed be pervasive in many industries, network externalities only exist if the market equilibrium exhibits unexploited gains from trade, implying market failure. Given rational expectations, it is likely that the resulting market outcome is pareto-optimal. Assuming that the government does not have superior asymmetric information about the projected network size, the government can do no better than private agents in orchestrating the education investment decisions of the people, even in the presence of uncertainty. Furthermore, the network effects, both direct and

indirect, while they exist will be completely internalized by private participants if they have perfect foresight.

However, Katz and Shapiro (1992) note that in the presence of uncertainty, it may be possible for individual consumers to limit adoption due to the lack of willing customers to be the "guinea-pig." This is a problem due to risk-aversion, and may result in difficulties for a network product to reach critical mass. Critical mass is the point where the benefits from increased network size mitigate any risks inherent in the adoption process. In the context of education in a developing country, where the opportunity cost of education could be high in terms of lost income on the farm or with current employment, families are typically slow to begin sending their children to school unless compelled or strongly persuaded to do so. Going to university may also represent a riskier venture for people in developing countries than in developed countries. This may be due to uncertainty, where future job prospects are not yet proven and it is uncertain to individuals if they will in fact recoup their investment. If a government is able to persuade risk-averse individuals to pursue education, it may help to overcome initial adoption hurdles.

A related problem in developing economies is the existence of highly inefficient capital markets. Without efficient capital markets, it is difficult for individuals to get market-rate financing for educational investments. Because the investment for education is high in relation to the income of an individual, this is often a prohibitive constraint on individuals in developing countries. In the model discussed above, these restrictions can be incorporated as part of the budget constraint.

The model discussed above is also consistent with Acemoglu's (1996) micro-foundation for social increasing returns in human capital accumulation which focuses on the effect of costly search. The idea is that workers have to make a large part of their human capital expenditure before they know what occupations they will get, and firms will have to make a decision on the technology to use depending on the workforce available. Because of imperfect matching based on imperfect observability of a worker's abilities, the average level of education becomes an indication of workers' abilities. Workers are therefore

able to benefit not just from their own level of education but from an increase in the average level of education and if this occurs, it will create a higher incentive for firms to invest more in higher-technology operations which will in turn cause potential workers to invest more in education. However, workers and firms are unable internalize this due to imperfect information and costly search.

Furthermore, because of incomplete contracts, there is under-investment in technology by the firms, and under-investment in education by the workforce. This is because there is no way for potential workers to contract with a firm guaranteeing a job prior to engaging in education, leading to costly search and imperfect matching and therefore under-investment in education. This is not strictly true, though, as scholarships have been used by firms in developing countries as a means of engaging in exactly these forms of contract, although they are few in number and restricted to the best students. Interestingly, though, scholarships offered in developing countries often come with a bond, which legally requires the student to work for the firm after graduation for a specified number of years. Such contracts come with a liquidated damages clause. In developed countries, scholarships do not typically come with a bond. This reflects the different contracting requirements for educational investment in the developing vis-à-vis the developed world and may be due to costlier job search in developing countries, or greater job mismatch due to a smaller pool of possible occupations in the network effects model.

Furthermore, Acemoglu (1996) finds that highly trained human capital tends to migrate to areas that already have high levels of existing human capital. Lucas (1990) notes that this provides an explanation why physical capital does not automatically flow to underdeveloped countries. Physical capital goes to where human capital already exists. In the above model, modeling the number of occupations in each *group* as an increasing function of the number of people with that educational level takes this into account.

One would expect that network effects be larger in the developing world because diminishing returns to these network effects in education have yet to set in compared to within the developed world.

The possibility for these network effects being network externalities is also higher in the developing world because of the presence of more inefficient capital markets, higher search costs, higher mismatch costs, and higher risk-aversion. If this is so, we ought to find higher ratios of social to private rates of return to education in the developing world than in the developed world, which in fact seems to be the case. All this seems to suggest that government intervention in education in developing economies is more justified. However, it has been commented that the likelihood of government failure may also higher in the developing world. The ability of on-the-job training to substitute for education is also an interesting observation. If firms are in fact able to provide on-the-job training, it might be more effective for governments to take the approach of providing training subsidies to companies, instead of providing education to individuals through traditional schooling.

6. Education and the "Hardware-Software" Paradigm

In addition to the *communication network* paradigm discussed above, the network literature also considers network effects that arise from the "hardware-software" paradigm. In this paradigm, a "hardware" is a good that provides a platform upon which other services or goods (called "software") are provided. In this paradigm, education is perceived of as a platform upon which complementary economic activity is carried out, for example, the viability of libraries, museums, newspapers, magazines, books, computing, and other technologies, all depend on education as a basic complementary requirement. In Figure 4 below, the complementary relationships between components involved with education are laid out.

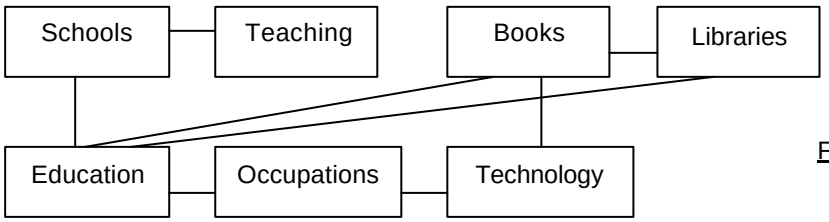

Figure 4

The direction of the arrow indicates the "hardware-software" relationship, i.e. the arrow points in the direction of the "software". Relationships without any arrow indicate pair-wise complementarities, in other words, the two goods are used jointly in production and do not have a "hardware-software" relationship. The "hardware-software" pairs that can be identified include "schools-teaching", "education-occupations", "education-books", "education-libraries", and "libraries-books".

A "hardware-software" system is a specific pair of complementary goods where the relationship between any "hardware" to its "software" is one-to-many. This fits the conceptual idea that the "hardware" is a platform for a variety of services and goods. In addition, the "hardware" is useless without "software" and vice versa. The value of a "hardware" increases with the number of "software" that utilizes it as a platform. Furthermore, it is common to have multiple competing "software" utilizing the same "hardware".

Figure 4 above therefore can be interpreted as follows:

- Schools provide the basis for teaching (teachers, syllabus, etc…), and there is a large variety of teaching that can be implemented with schools.
- Schools provide education, and education is not possible without schools. Although this may not strictly be true in reality, it closely enough reflects reality for the purposes of policy.
- Education provides the platform for books (includes newspapers, magazines, etc…), libraries (includes museums, information systems, etc…) and occupations. There are a range of books or libraries that are compatible with any particular education system (i.e. people who have a certain education can assimilate a wide range of books), and libraries in turn are also a platform for a wide range of books. There are a wide range of occupations that can result from the existence of a particular education system.

- Occupations require implementation of technology, and depending on the type of occupation it will imply a different technology but the relationship between any specific occupation and technology is assumed to be one-to-one.
- Technology requires books, and depending on the type of technology it will imply different types of books but the relationship between any specific technology and type of books is assumed to be one-to-one.

7. Network Externalities in the "Hardware-Software" Paradigm

Note the relationship between Figure 3 (the communications network paradigm) and Figure 4 (the "hardware-software" paradigm), where occupations are concerned. The value and therefore the demand for "hardware" (i.e. education), depends on the extent of the range of "software" that it supports. The existence of more occupations will result in an increase in the demand for education, which is consistent with both the communication network and the "hardware-software" paradigms.

Katz and Shapiro (1994) note that when both "hardware" and "software" markets are perfectly competitive; there is no welfare cost and therefore no externality. This is because both products are being produced at marginal cost and there is free entry and exit, leading to an optimal number of "hardware" and "software". However, perfect competition is only likely in the "hardware" market if the good is not a *communication network* and does not exhibit network effects typical of those goods. Otherwise, perfect competition in the "hardware" market requires the assumption that the total market size is large enough for a large number of producers at a scale beyond that which network effects still exist. Otherwise, *tipping* will occur and market concentration will increase.

More interestingly, if the "hardware" market is not perfectly competitive and exhibits network effects at current production quantities, but the "software" markets are perfectly competitive, expanding the production of "hardware" will lead to both direct and indirect network effects, and there will be

welfare gains from increased production of both “hardware” and “software”. There will also be new entry into the “software” markets due to the indirect network effects. This illustrates how supply imperfections in the presence of network effects (even if these are internalized), may result in deadweight welfare losses that exceed those in traditional monopoly analysis. As a result, the “hardware-software” provides additional justification for the subsidization of the “hardware” good, in this case, education.

If the “software” market is also not perfectly competitive and price is above marginal cost, Katz and Shapiro (1994) notes that subsidising “hardware” will lead to increases in “software” production, raising welfare. This is the case even if there no network effects exist in the “hardware” good. This is based on the standard analysis regarding a pair of complementary goods. However, it has to be noted any subsidy to “hardware” affects all the “software” products, i.e. the books and libraries as well, and the extent of the effect on each will depend on the existing market structure and conditions in each market. Any subsidy to education may then have beneficial spill-over effects into multiple markets. This is an argument used often in support of subsidising *essential utilities* such as electricity and water, and to a certain extent applies to education as well. Furthermore, subsidizing “software” is usually administratively prohibitive compared to subsidising “hardware” (since there are many “software” and one “hardware” per system), which leads to an even greater tendency to subsidize education.

Since subsidies have a distortionary and negative welfare effect in the absence of clear market failure, care should be taken in employing subsidies if network effects do not exist, or have ceased to exist at current large network sizes. The reason is two fold. Firstly, the absence of network effects suggests that any possible gains from a subsidy due to an increase in output will be limited. Secondly, it also implies that any tendency of the market towards further imperfection is unlikely. Implementing subsidies may result in distortions that resulting in further concentration of the “hardware” market, which may have negative welfare impacts. The problem with subsidies is that once it is given, it is often politically unattractive to reduce. Even of subsidies are justified at the early stages of the education network, it may become an

inefficient burden further down the road when network effects are exhausted by diminishing returns in network size.

Another possible source of externality in the "hardware-software" paradigm comes from commitment problems in the provision of the "software" good. When there are market imperfections in the "software" market, the "hardware" and "software" providers may not be able to commit that there will be enough "software" available to make purchasing the "hardware" worthwhile. This is analogous to the problem discussed earlier about people in developing countries who under-invest in education because of fears of not being able to recoup their investments from future career opportunities. While the cause of the problem in the earlier case is risk aversion in the context of uncertainty, the source of the problem here is commitment and coordination failures.

Economides and Salop (1992) show how vertical integration gets rid of this vertical externality. By vertically integrating and producing both "software" and "hardware", the "hardware" firm can commit to producing enough "software" in order to justify the purchase of the "hardware". In the context of education in developing countries, consider a typical situation where there is an adjustment cost that needs to be incurred in order to restructure industry or to allow foreign direct investment to enter the country that needs to be undertaken by the government. This action needs to be taken before higher-technology industries are able to operate in the country, making education worthwhile. If education is produced by private agents, there is probably no way they can commit to ensuring that the government will take the necessary actions to achieve the desired changes in industry, and neither can the government commit to keeping its promise on these industrial policies. Individuals will therefore shy away from investing in education. However, if the government vertically integrates backwards and provides education as well, then there will be a vested interest for the government to carry out those industrial policies as promised, and individuals will be more likely to invest in education. This helps to explain why governments, especially in developing countries are quite adamant in providing state-run education, aside

from the usually cited reasons of equity and standardization. This point also highlights the perils of treating education in isolation and stresses the need to consider education policy in developing countries as part of a larger suite of industrial and technological policies.

8. Conclusion

This paper takes a small step in introducing the economics of network effects and externalities to education. This approach characterises education as a good that when consumed, provides the consumer with access to a network, typifying the traditional understanding of education as a means of "opening doors to new opportunities" for individuals. The value of connecting to the network (could be defined as technical diploma holders, or graduate engineers, for example) varies with the size of the network and the availability of complementary goods (such as career opportunities, libraries, books or technical journals).

The study of network effects in education can have far-reaching implications. The next step will be to algebraically formulate the model so that it can be brought to data. Typical approaches in the network effects literature include hedonic demand and price estimations. The aim should be to quantify the externalities in education as well as internalised network effects. One can also carry out research evaluating policies such as universal primary education, the effects of choosing a different language of instruction, or the option of implementing a uniform syllabus across all schools. Studies should focus on the role of the government in alleviating market failure in the provision of education, estimating the decline of positive network externalities as education becomes ubiquitous, and considering when privatised education is likely to be superior to publicly provided education. The existence of network effects may also contribute to explaining within-country migration patterns and the brain-drain phenomenon, or even cross-country differences in wages for people in the same occupation.

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