

Economic and Pedagogical Analysis of an Alternative Model of Engineering Education

Part 1: The Philosophical and Pedagogical Basis of Postsecondary Education¹

Within the last five years there have been a number of contradictory studies about the impact of automation on the workforce. At the pessimistic end of the spectrum Frey and Osborne argued that 47% of today's jobs in the U.S are at risk of "computerisation" [1]. At the optimistic end of the spectrum the Organization for Economic and Cultural Development (O.E.C.D) suggested that across countries 9% of jobs are at risk of being automated although half of the tasks for another 25% of contemporary jobs will change significantly because of technological change [2]. In either case there are likely to be considerable changes in the structure of the workforce although they will not be spread evenly across employment sectors. It is likely that some jobs perceived as high skill will more likely be affected [3] for which re-training or different initial training will be required.

Recently Acemoglu and Restrepo have argued that in spite of such papers there is little understanding how automation in general, and AI and robotics in particular, impact on the workforce and productivity [4]. They consider the optimist/pessimist dichotomy to be false, and present a model for thinking about these issues that is based on the tasks that have to be done.

At the levels of the blue collar worker (skilled and unskilled) and lower skilled white collar worker the impact of changing technology has been profound, particularly on those who are unskilled. However much the reports disagree it is clear that changes in the structure of the workforce will continue unabated, and that the fewer skills a worker has the more they will be at risk, unless they are in non-repetitive jobs (e.g. cleaning, gardening) at all levels. Moreover, at higher levels many jobs are likely to change, and the number of co-robotic jobs will increase substantially [4]. Of that there seems to be little disagreement.

Lolade Fadulu in an article in *The Atlantic* [5] reports on the response of Nigel Cameron the CEO of the Center for Policy on Emerging Technologies to these developments. His main concern is that politicians and policymakers have avoided conversations about the future of work or lack of work. This, in spite of the fact that it is the subject of repetitious comment in the press.

Asked, why this should be so? Cameron replied "[...] *the agenda is almost always an agenda [made with past issues in mind]. I think this is one of the reasons there's an enormous gap between the culture of Washington and the culture of Silicon Valley, where people talk about the future (future-oriented) technology questions all the time. But the culture of Washington is locked into the past. So anything which is changing and changing fast finds it almost impossible to get a look in*". Given that engineers are in large part the cause of these changes, they have a responsibility to ensure the problems they create are the subject of public/political discussion. However, the historical and systemic lack of response to high level reports [6]–

¹ Supporting materials can be found here: <http://www.tara.tcd.ie/handle/2262/82160>

[9], especially in the U.S., suggests that the effects of rapidly changing technology will come upon Engineering Education unawares. As with the lack of response to past reports—which in their essence document similar problems—engineering education will in a better position to face the problems brought about by socio-technical change if there were more attention to the broader context in which engineering education takes place.

A striking feature of Government policies is that although politicians may be rear facing they never look to what happened to policies or policy documents in the past. For example, Carnevale in an interview with Lolade Fadulu (Nov 16th 2017) [10] said that “*the American K-12 system does not make people job ready, it makes people college ready*”. The purpose of school education, as Carnevale puts it, is to get the child into Harvard.

There are two points about the social preference to get one’s children into high status universities. The first is the ever increasing cost of higher education at a time when incomes are relatively flat. The second, is that this criticism of K-12 education has been repeated at regular intervals but the most significant report, The SCANS (Secretary’s Commission on Achieving Necessary Skills) report that included a curriculum model that was both academic and vocational, published in 1990, was totally ignored [11]. It remains highly relevant, as do other reports relating to higher technological education of the same era in the UK [12]. Similar ideas of curriculum outcomes are to be found in these reports [13]. Carnevale also points to the failure of apprenticeships in the U.S. in comparison to the success of the German system, but he might as easily have focused on the failures of the British system

Similarly Cameron in his conversation with Fadulu says that it is “*quite naïve to believe that STEM is the answer [...] If [we produce] a lot more people with technical skills in the STEM area, they will be arriving at just the point robots will have taken over our machines [...] The jobs that go first will be the STEM jobs.*”, a view that is supported by Carnevale.

“*The kind of skills that will certainly survive so far as we can see are things like entrepreneurship, things evolving into personal skills, jobs in bringing people and machines together, helping people work with the machines and the machines work with the people-interface jobs. These are human type jobs in which human skills, human capacities, understanding people- these are the sort of things that machines are going to find much harder to do. I think we all need to understand machines. So, yes we all need to do some STEM stuff. But the notion that pushing STEM creates more secure jobs, I think it’s fallacy*”. On that basis given recent discussions in the TELPHE Division and the resultant report [14] suggest that technological and engineering literacies that need to be pushed. Such literacies prepare individuals not to necessarily work in technology or engineering (although they do not exclude that) but rather to understand broadly the underlying nature and impact on technological products and the processes that produce them. In brief technology is the thing (product) that results from the activity of engineering (process).

It is clear for these levels of work that in the future workers will have to become much more adaptable than they have been in the past. The question arises as to whether the jobs associated with the professions will be affected in the same way, and, if so, do the professional organizations and societies behave in the same way as the Government, that is look to the past, or Silicon Valley, look to the future?

The evidence is that those involved in education tend to be 'past' rather than 'future' looking, and we suspect that in this respect engineering is no exception, even though there have been a number of papers published on the topic [15].

Surprisingly, while much has been written about the impact of technology on the professions of law and medicine, very little has been written about its impact on engineers, yet it is improbable that they will remain unaffected. For example, there may be a shift in jobs available from the professional level to the technician level but it should be remembered that predictions are notoriously difficult at this level [16]. Even if it were not, engineering education has a sufficient number of problems to suggest that it needs to consider alternative models of education, and make available more pathways to engineering than are currently available. Such models are concerned as much with the structure of the system (e.g. full time course versus cooperative course) as they are with curriculum content and pedagogy) [17]. The answer to these questions cannot be considered within engineering education alone, but must be framed in the larger complex ecosystem to which engineering education contributes.

There are several factors that support this contention:

1) Knowledge redundancy and job redundancy.

Knowledge redundancy, job redundancy and work structure are inter-related. There is some evidence that when middle aged (and above) engineers are made redundant that they find it difficult to obtain new employment [18]. While this may be partly due to the unwillingness of employers to pay high wages when younger people are available who possess the knowledge/skill required, it may also be due to inflexibility on the part of the engineer. That inflexibility may be due to many factors: among them might be inadequate initial education and training. It has been found, for example that middle aged engineers tend to value experience and believe they have little to gain from further training [19].

It is clear that that knowledge redundancy will continue to impact firms and individuals in them. A major problem is that industry it is finding it increasingly difficult to predict what skills it will require five years hence, let alone ten. Clearly it will have to make provision for re-training, or continuing professional development (CPD) as it is now called. A key question is, "what role, if any, do universities have in preparing students to participate in the industries of the future?" Similarly, in rapidly changing socio-technical systems do universities have a role to play in worker retraining or more broadly to contribute in some way to broad public education of those who are past college age?

2) The College-Industry Gap

There has been a succession of complaints by certain industrial organizations that the output of graduates from universities are not immediately suitable for work in industry. One of the persistent complaints has been that they lack interpersonal and professional skills. More recently the complaint has been made that graduates are not sufficiently adaptable in the sense they are unable cope with the learning requirements of the tasks with which they are faced.

It has been argued that this difficulty arises from the fact that college courses focus on embedding knowledge which is assessed by narrowly designed questions. An alternative which is said to get over this difficulty is the cooperative course. One or two institutions

have set out to design problem based cooperative courses with the purpose of better integrating the needs of industry and academia.

However, the perception of such a gap continues to present serious issues for both academia and industry in that some large organizations are now proposing to establish their own universities, and in one or two instances, as for example Dyson in England, are not taking students. Given that the values of industry and universities differ considerably it will be interesting to see if these universities can bridge the academic vocational divide. Tied to this issue are larger questions of the role of the university not only in workforce preparation but in contributing to civic engagement, citizenship, and development of the person.

3) *Financing of higher education*

Higher education continues to increase in costs [20]. While there is significant data on the historical return on investment of college (Figure 1) which shows the economic value of going to college, at the same time the axiom that higher education is directly correlated with economic growth no longer seems to hold.

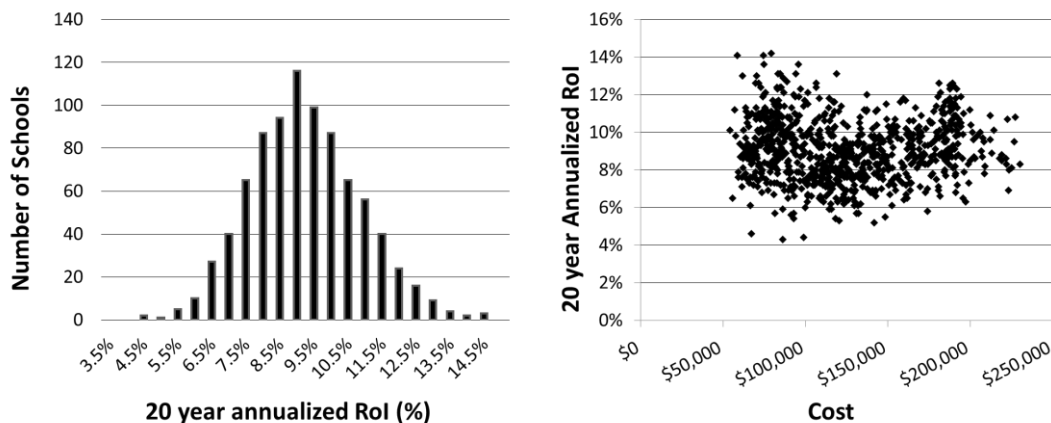


Figure 1: The top figure shows return on investment (RoI) plotted as a distribution over schools. The bottom figure shows the RoI as a function of cost-of-degree.

A portion of the reason for separating education from economic growth is that except at the top income percentiles average income has remained relatively flat for decades (Figure 2a). Due to the increasing costs of college over time the costs to families as a fraction of their incomes has increased substantially for all but the wealthiest in US society (Figure 2b). If these costs continue to increase there will come a stage when the number of students seeking loans will begin to fall, impacting enrollments, and thus the financial future of many universities. Similarly the debt accumulated as a result of going to college hinders other investment. Therefore, it is necessary to seek ways of reducing costs which is major, but little recognized, challenge for engineering education. The use of computer assisted learning to provide the knowledge is already being promoted as an alternative. Clearly, there is no need for a lecture if the same material is available by alternative methods and can be at a time and paced to suit an individual. Considering the effectiveness of such online learning as the only metric, as educators are wont to do, is foolish. What will increasingly drive adoption of automated learning platforms at all but the most elite institutions is effectiveness vs. cost [21]. If there is no need for lectures, and laboratory work can be simulated, what is the purpose of a university other than as an aid to social

mobility? A university is only required if it can do things that are not provided for by current arrangements. It is a clear and present need for higher education to articulate what these things are. Placing the responsibility for financing their higher education has led to complaints by students about the quality of the instruction they receive since it increasingly places them in the role of consumers rather than learning.

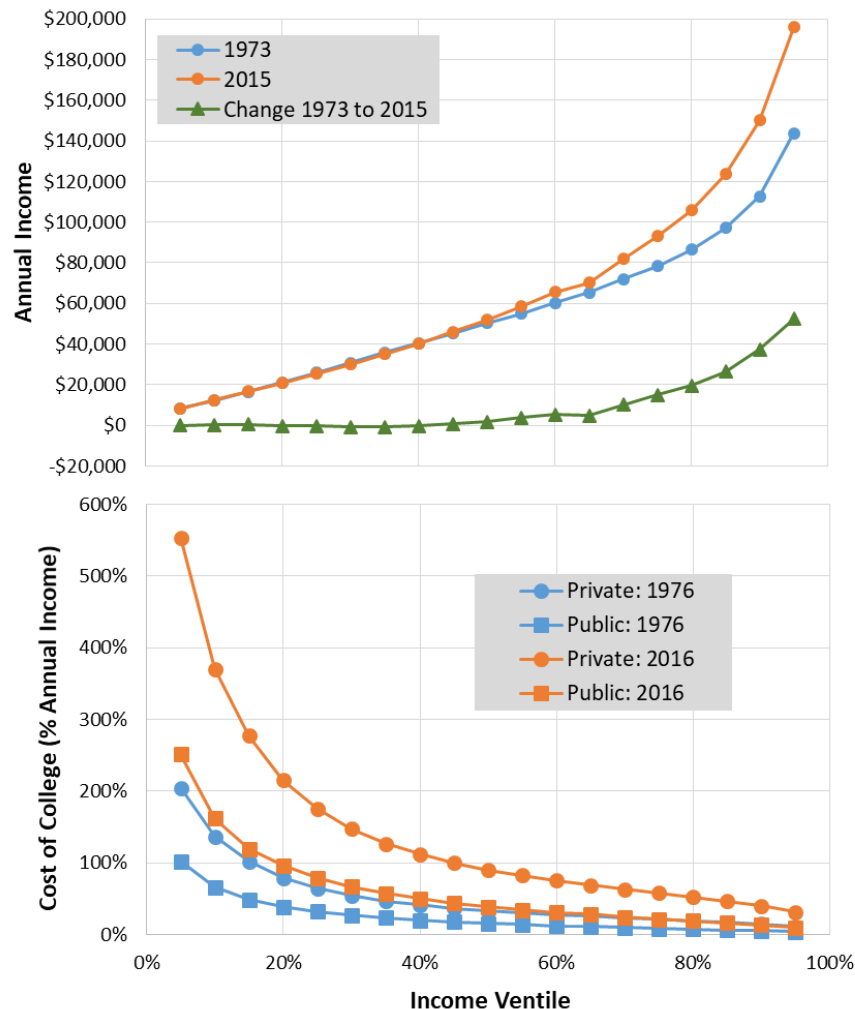


Figure 2: The top figure shows the divergence in income between 1973 and 2015 in constant dollars. The bottom figure is the cost of college as a fraction of annual income by income ventile (average tuition exclusive of discount) for the same years at public and private institutions.

4) Defects in the aims of higher education

Policymakers take a utilitarian approach to higher education. Its principle is that it is an economic good, and the more there is of it in certain subjects, the more the economy will benefit. Its participants are commodities, and in consequence the institutions of higher education are simply business organizations marketing “prestige” which in turn drives enrolment selectivity and leads to increased prestige. Similarly, the participants should be directed towards the courses that bring them the most benefits. A major problem for this

model is that for one reason or another students do not behave as rational economic actors and many for reason of aptitude and interest take courses that are not economically beneficial in terms of higher education. That is, the jobs they acquire as a result of their qualifications may not bring a return such as to enable them to pay off their student loans.

This model assumes that there is an economic good from which students benefit, therefore, they should pay for their higher education. No account is taken of the social good that such an education might bring either directly or through the personal development of the student. Nor is much notice taken of the fact that this good is increasingly less to those at the lower end of the income distribution without taking on significant debt or being able to obtain scholarships. Any alternative model would have to take these dimensions into account.

An alternative model of higher education

There are several assumptions that underlie the arguments made in this paper. First it is assumed that an individual will have to make a number of job changes in life that depart from linear career progression. Second given that employers find it difficult to predict what skills and knowledge they will require because they cannot predict how new technologies will affect them, then the need for both employees as well as employers to have to make provision for continuous professional development will increase. In so far as employees are concerned this may have to be for the purpose of obtaining a new job while from the employer perspective it is to keep one's firm competitive. Third as changes occur in society and the economy an individual will be faced with many issues that predicate the need for continuing personal, as distinct from professional, development. It follows that compulsory schooling only prepares students adequately for participation in society or work should such school equip the individual for continual learning or if changes in society are slow compared with a human life span. Furthermore should too much emphasis be placed on preparing students for the workforce they may leave school with a deficit of the personal qualities essential for personal equilibrium.

From these assumptions, which stem from the rapid changes that are predicted in the workforce and society [22], there will likely be an ongoing need to equip adults as well as children in social and personal skills and fits in with what is known about adult development [23]. Two points arise from these assumptions. The first is that professional and personal development go hand in hand and cannot be divorced from the social context in which such development takes place. The second point is that it is necessary to treat education from cradle to grave as a continuous system. Decades ago the O.E.C.D. used the term "permanent" education to describe such a system of education that was accessible to everyone thus serving issues of equity and justice. It seems appropriate to the term Lifelong Learning Education System (LLES) to describe the system proposed which differs from the current education system in that it is not as exclusively weighted towards an individual's formative years.

In brief it is proposed that following some level of basic education everyone would be entitled to a small number (say between 3 and 5) of short formal educational interventions during their life span; perhaps supplied and accredited by the university from which they graduated. This change from the view that education prepares one for the rest of their life is incomplete since it leaves unanswered questions about both what revisions are needed to the structure of higher education to support continuous learning as well as how the purposes or aims of higher education would need to shift. To understand what shifts might be required it is first

necessary to frame the assumptions inherent to current structure of higher education and where these structures and the models they give rise to may need to be adjusted.

While there is no end to suggestions on how to change the processes of higher education, the larger question is what aim should structures be realigned to support? Clearly education needs to impart knowledge and skill, yet the literature on higher education tends to confuse the terms “knowledge” and “skill” in the sense they are often taken to be synonymous. It is important when discussing the aims of higher education to try to make a sharp distinction between the two, in spite of the difficulties that arise with such concepts as “communication” which is used to describe an academic subject at the same time as it is used to describe skill. Yet knowledge and skill are not the sole purpose of education [24] since personal development also addresses “being”, “agency” and “identity”; terms which are also often confused. Without wanting to become someone else (ambition and or identity) there is no purpose to the pursuit of knowledge and skill. “Becoming” is how we gain the experience from which wisdom as it is commonly understood is derived through self-reflection.² Academic courses tend to emphasise knowledge at the expense of as skill and rarely directly address being [24].

Yet knowledge, skill, and a sense of identity and agency are of little use in a world in which rapid changes give knowledge and skill finite lifetimes. Thus a more important question may be how does an educational organization ensure that graduating students are adaptable which is one of the demands that industry makes of colleges. Put another way how do schools prepare workers cope with technological change? One of us has argued that adaptability depends on a liberal education that has an epistemological basis of the kind proposed by Newman for the enlargement of the mind and has shown how engineering fits into the model [13]. Another way of considering adaptability is to look at it from the perspective of the transfer of knowledge and skill. For example, a person may be faced with taking a job that requires substantially different skills and attitudes to those developed in that person’s education or their career to date. If the individual can transfer relevant elements of their skill set they may be able to more quickly success in a new job. Similarly industry wants a person to learn different high order skills because of new technologies impacting on the business.

Given that knowledge delivery by lectures has a rapidly shifting cost:benefit ratio universities are faced with not only having to evaluate their curriculum but their purpose. Also, given the needs which will face graduates in the near and distant future, it is clear that universities should be preparing students to learn to be able to easily step into new roles, and if necessary design their roles to create value for themselves and their employers. Devising such models of education will likely require significant structural changes. Since the key issue faced by students once they leave college is that much of their knowledge is only valuable in contexts with change rapidly and are impacted by shifting technologies it is a reasonable hypothesis that such a curriculum would be problem based. Heywood has argued that such a problem-based curriculum will not require a three year programme and has demonstrated how a two

² These distinctions are explored in greater depth in the 2018 paper “Higher Education and Technological Disruption: Purpose, Structure and Financing” by Heywood, Cheville, Corbet, Larkin and Richey which can be found at at: <http://www.tara.tcd.ie/handle/2262/82160>. It is important to note that these have their origin in the philosophical work John Henry Newman (1801-1890) in his *Idea of a University* (1852), Alfred North Whitehead (1861-1947) in his *The Aims of Education and Other Essays* (1929) and John Macmurray (1891-1976) in his Gifford Lectures (1953 & 1954).

year curriculum would meet the needs and reduce the costs to students and provide a base for further continuing professional development. Another issue is how to fund such continuing professional development since current educational structures assume investment in education early in life pays off through returns once one enters the workforce. The time to recoup that investments shortens with continuous education. Cheville has suggested that courses structured in this way could be financed by insurance which is the subject of the second part of this paper.

Part 2: Funding Alternative Models of Higher Education

Education systems that are conducive to insurance models

While the intent here is to open a discussion on new structures which support continuous education, the models presented herein are intended for serious policy discussion. Thus the authors propose an application of a continuous education model in one or more US states with a state university/third-level system. At its most basic the model provides a network of different institutions to offer an initial problem-based education experience (i.e. the 2-year programme of learning how to learn) and another supporting network of institutions to deliver specialist subject knowledge. The subject knowledge may be provided in classroom/labs, remotely via digital technologies, in concert with industry, or through a combination of methods. Given the key goal of providing ongoing education for less cost, a trial of the model will be needed to develop a much more precise understanding of student education costs.

Given the significant structural changes—both in university organization and financing—should serious attempts at continuous education be undertaken, it is important to understand the types of education systems in which new financing models make sense. The education system that can work with the model proposed here needs to either be: (1) connected to a small proportion of the student profile, approximately the top 18% of the distribution of the school-leaving cohort; or (2) implemented in a much wider system where near universal postsecondary education is the norm. The second option reflects the origin of the model in Ireland, where postsecondary participation rates are approaching 70%, with government policy objectives to increase that figure. Other small open economies of Europe, such as Slovenia, also have high participation rates (approximately 80%). In the context of the US, it is best to look at this proposal as one that works based on a state-by-state system and not as national system, considering each US state to be a small open economy with certain endowments, social policy objectives and fiscal conditions.

The key requirement of this (or any) model is not how to provide the education but rather to pay for it. This requires the financial engineering be allowed to act as a monopsony (single) buyer and “bend the cost curve” of higher education while still delivering outputs that can be effectively placed in the labour market and maintain social cohesion and stability. These set of parameters allow us to look at an insurance-base model and possible financial engineering solutions.

The Idea of an Insurance Model

The insurance model proposed subsequently is informed by discussions of John Heywood and Alan Cheville who draw on technological literacy, the philosophy of Alfred North Whitehead on the stages of education [25], and Newman’s ideas of liberal education [26].

The model assumes two years of a basic, problem-based education, but these initial two years could constitute with the close of secondary education or a pre-higher education course explicitly aimed at teaching students the methods of how to learn generally and a light introduction to subject knowledge. In either case it is assumed that those 24 months are supported in some way by a large subsidy.

Right now in the US and an increasing number of European countries higher education is based on what might be simplistically called a “mortgage model”. Here payments for higher education are the responsibility of an individual (or their family, scholarships from charitable endowments, etc.) as well as some government funding at public institution. The individual makes a large upfront payment by investing their education and increasingly pays off the loans needed to fund that investment over a long period of time. This is similar to how most individuals buy a house by taking out a mortgage. The alternative model is more like another common investment, that of an insurance policy. Here an individual (and often their employer) contribute small regular payments which pay out when a catastrophic event occurs, i.e. a trigger. It is argued here that by shifting from the mortgage based model of higher education to an insurance model it can allow the creation of an educational structure that allows for lifelong learning.

The structure is as follows: eight triggers, ideally no individual triggers more than four (think of this model in the way an insurance underwriter looks at the likelihood of serious medical events or vehicle accidents). In this terminology a “trigger” is when an individual needs additional education. From a financial point of view triggers one to three are expected to be used, with the majority of individuals only using triggers one and two. Trigger three will be used by less than one-quarter of school leavers. Trigger four will be used by around 10%. Beyond trigger four will be expected to be relatively rare.

At present, most advanced economies offer some form of a child tax credit or a direct cash transfer to parents. In our model, we change this from a model of tax expenditures or cash transfers to a lump sum bullet payment to each child in the state which in Ireland would be around €36,000. Alternatively, an investment can be made for this purpose by family, where there is no existing demographically-aligned tax expenditure or subsidy. This would be placed in a growing asset at 2%, which result in a total endowment by age 20 of approximately €57,000. In the US this correlates with 529-type college savings plans [27]. Alternatively, a CPI-linked endowment payment can be made at age 20 that equals approximately €57,000. It is important to note that there are many tax expenditures that can redirected towards this form of positive-return capital investment. For example one of least effective tax expenditures as highlighted by the International Monetary Fund relates to household fuel and energy consumption which could also be considered a source of funds for this endowment.

This endowment represents an accounting measure, with the allocation of the endowment done by voucher or EFT (electronic funds transfer) directly to a state-certified educational provider or education accommodation provider. The size of the endowment is sufficient to ensure that specialisation at levels one and two can be fully accommodated by the endowment. This covers some basic continuing education for most citizens in the state or system. In the US this is similar to policy makers calls for universal community college.

The student has a choice of whether their endowment gets exhausted or re-invested. Spending the endowment would be similar to a student spending their 529 plan in a mortgage model of education. Re-investment will be crucial, however, if the student is to trigger multiple strikes during their lifetime. To encourage reinvestment the insurance model would seek others such as employers to contribute to premiums just as is done for health insurance. Students that appear to have potential in a high human capital industry, engineering for example, can be sponsored at stages 2 and 3 through the firm paying their education insurance premium. Medical students can have the Department of Health sponsor their education insurance. These payments can additionally be linked to employment and service contracts that specify limited duration employment to allow the firm to realise a return on investment. These service contracts can also include student and institutional key performance indicators adding an additional layer of security to the investment. Students who wish to go on to further education would redirect their endowments towards paying the education insurance premium. That payment can be supplemented via external sources (i.e. out-of-pocket) or through an employer payment, similar to employer-sponsored health insurance perquisites common in many large firms. Those students who cannot get jobs or that become unemployed will have their education insurance paid by the social insurance provider in the state (Department of Social Protection in Ireland).

The education insurance structure will be operational from age 20 to age 65. Students can choose what level of education insurance they wish to purchase and vary this over time subject to number of specialisation strikes and the human capital intensity of their sector to provide some flexibility in response to life circumstances. High human capital sectors and firms will seek high premiums and pay those for access to education. Those with low human capital intensity can use a lower premium. The premiums thus provide an additional signalling process for students as they make choices about which firm to work for following graduation.

The initial endowment, for many, will not be exhausted, even with the support of the premium being used by some for all or some of their working lives as it is expected that employers will play a large role in supporting premiums. That initial endowment can be made inheritable or transferable upon death of the incumbent holder as named asset upon payment of a very large additional fee. In this way those who do not take advantage of their educational opportunities can pass them on, which can help make such a plan more politically feasible. In most circumstances, the initial endowment will revert to the education insurance company upon the death of the incumbent, thereby assisting in solvency.

From age 65 until death, the endowment, if not exhausted, can be redesigned, for a fee, as an additional retirement annuity. The same conditions on this annuity as existed for the education endowment apply. All education after 63 will be provided via direct out-of-pocket payments to the educational establishment, with the endowment going into a period of suspension until the death of the incumbent unless the annuity or intergenerational options are purchased by the endowment holder.

In summary, education from ages 1-20 is provided 100% by the state. Upper secondary education and the first 2 years of undergraduate students are redesigned to better dovetail into each other. More advanced education (i.e. a BA or BSc) takes place by triggering an option, called for example "Specialization 1". Advanced technical education in a specialization, such

as fully accredited engineering degrees takes place in stage 2 while medical and legal education (MD, JD, BL) takes place in stage 3 and so forth outward. The stages are designed to be discreet units so the application of barrier options can be used to go up or down the national qualifications framework. This structure also offers options for certificate courses or vocational retraining should someone need to be retrained or return to school following a lay off.

Should a student during their working career (past age 20) need or want to get additional education the specialization units can be paid either from the endowment and/or education insurance. At the outset, the insurance instrument is community rated with everyone paying the same premium, only those that go to level three and up would see a big increase in their premiums. Those that trigger level five experience an additional step function in their premium with annual insurance premium costing from €170 to €3800. This can be thought of as being in a car accident, the more people you hit over time the more you pay in insurance. Thus if you want to be a doctor, you will pay a bit more and your premium remains high. If, on the other hand, you want to do classics you can pay for your degree out of your endowment and then pay a €170 per annum premium for the time in the future you take a basic accountancy course to improve your labour market outcomes.

The core idea is that people, as much as possible, should never see money being given to them or taken away from them. The child benefit is financed partly by taxation and partly by a Perpetual (Consol in UK parlance, similar to a Cinderella bond in Wall Street jargon) that carries an interest rate of 1.5%. The company that offers insurance is centrally owned by the state or is like Fannie Mae or the USA and will pay a dividend every so often.

To summarize, the following scenario shows how this model might work in practice. Following the end of public education around age 20 a person who wanted to continue their education would elect into the education insurance pool. They could either choose to pay the annual premium from their endowment, have the premium paid for by their employer (if they were in a human capital intensive field), pay out of pocket if they chose to be self-employed, or have some form of social welfare cover the premium if they were unemployed. For those students whose academic records indicate that further education would be a good investment there would be a “draft round” with employers, where the benefits offered include high premium packages of education insurance on the basis that (a) the student will need it and (b) the student will have a high return on investment (ROI) as a human capital asset. Such employer buy-in spreads costs and builds up positive cash flow early in the program. Reinsurance will be provided by a government entity (e.g. NTMA in Ireland) in order to keep costs low. In addition, as stated above, the endowment is designed as a tontine (an early form of insurance in which dividends increased as investors died) [28] reverting to the state (insurance company) upon death. If an individual did not take advantage of their endowment to continue their education they would have two options: 1) pay very large fee to make it inheritable and thus provide better education for their children or grandchildren, or 2) use their endowment to supplement the old age pension as an annuity. Any funds remaining in the initial endowment reverts to the insurance company upon death. To implement such a system a very powerful regulator will have to be co-designed with the education insurance company. The regulator for the Dutch health insurance system would be a good model to base such a regulator upon.

Next three key elements of the model are discussed that could be implemented at the policy level to fund lifelong, continuing education. The goal of offering the model is to stimulate debate on forms of financial instruments that could be used to pay for life-long, continuing education that do not bankrupt governments or individuals.

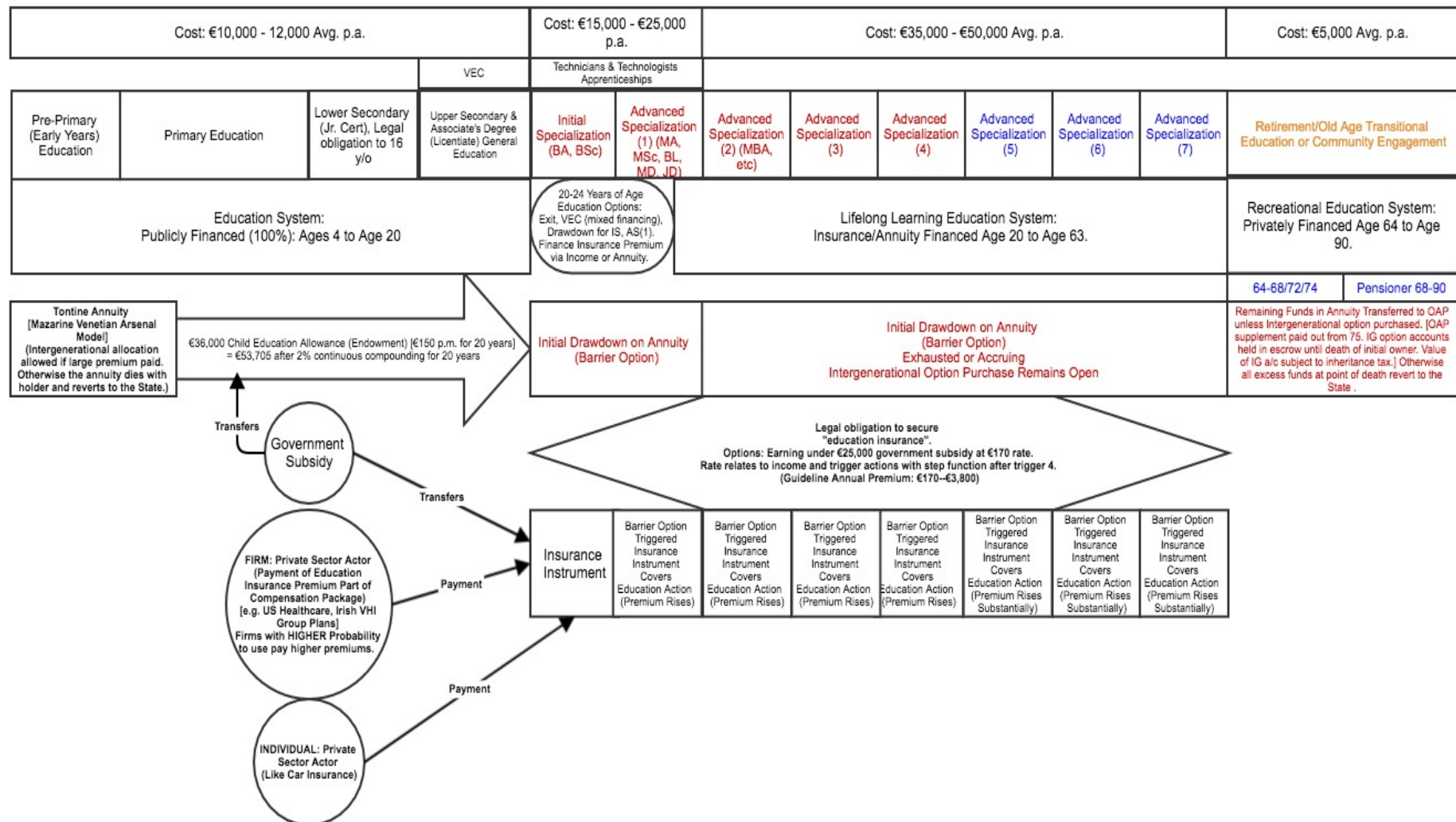
Model A: Insurance-Annuity exchange with barrier options model

After the completion of upper secondary education, the student will enter into the college education system, either through a degree, diploma or certificate programme, or a technician and technologies apprenticeship. Apprenticeships constitute a different track since they are connected to a shared cost of education, with part of the education cost being borne by the endowment and the wage payment to the apprentice being provided by the employer that the student is apprenticed to during the apprenticeship process. As apprenticeships are typically more expensive to provide compared to a normal BA degree, it would be likely that the student's endowment would be heavily drawn down and would need to begin topping-up insurance payment early in their career as a tradesman. This can be partly or completely addressed via wage supplementing insurance perquisites

This initial phase of college education will likely need to be restructured to direct students from upper secondary to a 2-year associate's degree programme, all of which will remain under public payment. "Senior" university for BA or BSc studies will be part of the initial specialisation supported by the education endowment. This is currently seen in the United States through various instantiations of 2+2 or 2+3 programs [29]. This first trigger of a students policy will then lead to an advanced specialisation, which is proposed to cost a maximum of \$/€30,000 per student per annum dependent upon the student's choice of specialism. It is then expected that the student will enter the workplace and enter the second stage of the Lifelong Learning Education System (LLES). At this point, the specialisms and programmes are selected based upon the necessitated skill and talent deficiencies of both the company and the student/employee. Therefore, the design of this system can add a multitude of added benefits including flexibility and specialisation of talent. Furthermore, young talent can benefit from the co-existence of work-experience and education simultaneously as programmes can be re-designed to facilitate part-time learning.

As described more generally above, and shown in Figure 3, there will be three proposed sources of financing towards the upskilling of each student: 1) a government subsidy that exists similar to that found in the Irish State education system; 2) the private sector company (Government Sponsored Entity or GSE) that has employed the student and is deemed partially responsible for their development; and 3) the private sector insurance-style (GSE) payment that has been paid both on behalf of and by the student throughout their life to the point in which they are seeking to add further educational development. The aim of the GSE is to avail of the lower cost of borrowing provided by being associated with a state.³ It is expected within our proposed model that the majority of strike-points would be utilised before the age of 30, therefore our selected methodology must represent this fact.

³ This can be complicated by a state that has a poor track record of fiscal stability. The fiscal stance of the government and the presence of fiscal rules will be important to ensure a low cost of funds.



One of the proposed financial products that can be used to represent the nature of our model is that of barrier options. At each strike point in area 1 in Figure 3, it is envisaged that this would be similar to the strike point being met. Once the next phase of education is over, the student then returns to full-time employment and continues to pay an education insurance premium. The premium will continue to be paid during education, just as health insurance is still paid while sick and will apply from the age of 20, drawing initially on the endowment and subsequently on alternative sources. Such premiums will be paid until it reaches such a value that the hypothetical option ‘strikes’ and the next stage of education is available. At the initial stages of 1 and 2 these will be very low option strikes. Strikes become progressively higher, reflecting the need for higher return on investment to recuperate the sunk costs of human capital investment. Should an employee pay into the system at a minimum level and be unable to accumulate the necessary funding for their barrier option to strike, they could seek aid from their employer, Social Insurance/Social Protection or increase their premium payment, either continuously or with a lump sum, which could be provided in a third-party deal contingent on academic performance and the proposed salary benefits that may be available due to added education. Specialised education will reflect the premium levels of the students. Advanced and specialised Level 9 or 10 (MA to PhD) work will reflect very high premium payments. Level 6, 7 and 8 will reflect lower payments (certificate, associate’s degree, bachelor’s degree). For example, a classics graduate in small firm employment that is paying their premium at a low level either personally or via endowment can take a simple level 7 accounting course via the accounting technicians body. A medical doctor pursuing an MBA would have had to have paid a high premium, either directly out-of-pocket or via the remuneration contract with the hospital to avail of this expensive human capital investment and will be subject to a higher premium in the future due to multiple triggers.

The above explains the proposed insurance model from the insured (students’) point of view. However it is perhaps more important to discuss how such models can shift systemic funding for higher education. As discussed previously shifting funding mechanism in ways that make continuous education affordable will be necessary for practical implementation of Lifelong Learning Education Systems. The following sections and Figure 4 describe how an insurance-based model might be set up, initially funded, and sustained.

Exercising Education Options – A Decision Model

The ability to exercise the insurance instrument in the future for LLES purposes will be via a barrier option. A barrier option is a type of option whose payoff depends on if the underlying asset has reached or exceeded a predetermined price. While barrier options are not a common financial product due to their complexity they offer specific advantages for the model proposed here. Barriers have the effect of lowering premiums because they provide more specific information on the alignment between an individual’s skills and their value in the market. Providing these options in effect adds transparency to the pricing of labor and skills. Additionally it provides the organization charged with running the insurance-based market additional options to balance revenue with expenses. A barrier option can be a knock-out, meaning it can expire worthless if the underlying exceeds a certain price, limiting profits for the holder but limiting losses for the writer. It can also be a knock-in, meaning it has no value until the underlying reaches a certain price. Barrier options are considered a type of exotic option because they are more complex than basic American or European options. Barrier options are also considered a type of path-dependent option because their value fluctuates as

the underlying's value changes during the option's contract term. In other words, a barrier option's payoff is based on the underlying asset's price path. Barrier options are typically classified as either knock-in or knock-out.⁴

When clarifying the loop of financing throughout our proposed financing model, we have attempted to use the lowest possible risk financial market products while leveraging upon the existence of agencies that already exist in State. Low risk make financial products attractive to investors which is a prerequisite for any form of higher education financing. Current student loans are considered high risk, which raises the costs for borrowers, thus creating lower risk financing models has multiple societal benefits.

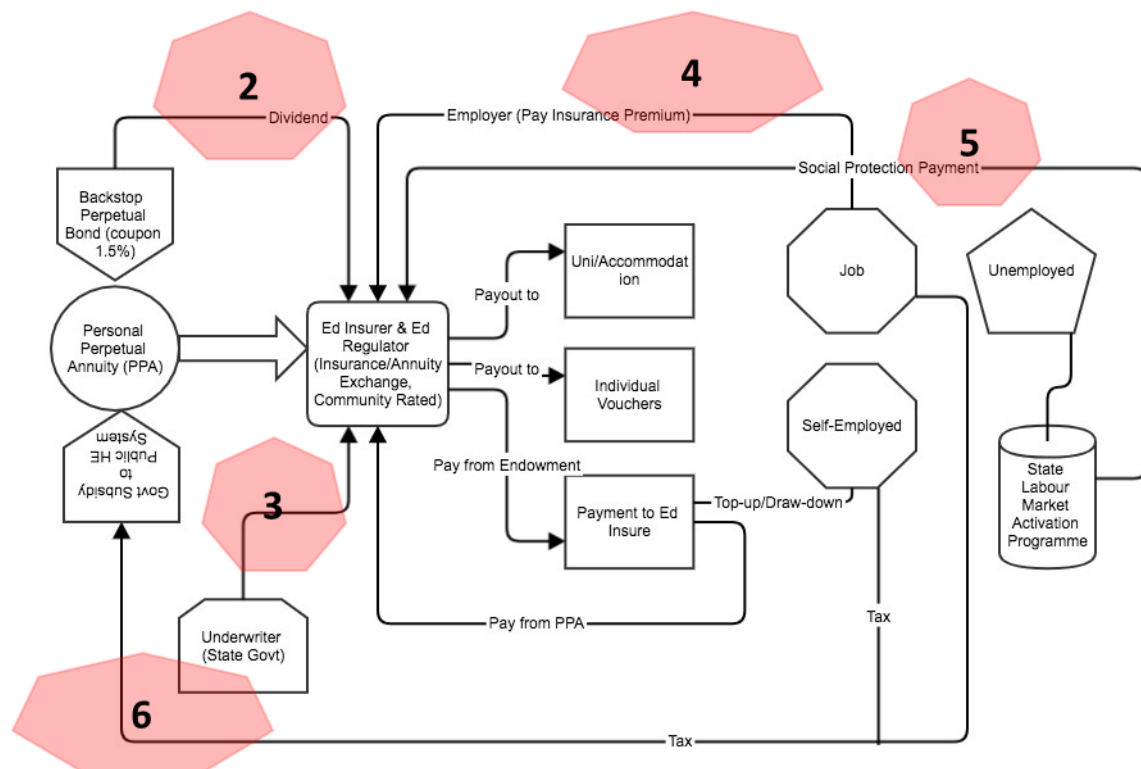


Figure 4: Flow of Funds: potential financing structure for the proposed life-long learning education system

While simplistic in nature, there are five key areas of risk that are prevalent within the proposed system. To facilitate the available capital to allow students to “strike” (continue their education), the education insurance system must underwrite a large government supported bond (with the government acting as a guarantor). This is represented in area 2 for Figure 4. While long-term bonds are preferable, in this system, and proposed time to expiry will create a “pinch-point” with the capacity to expose the system to collapse at the point of repayment. Should the system become self-sufficient at any point in the future, it would be proposed that the outstanding debt of this bond would be reduced as a priority. It would be recommended that the system be underwritten through the use of a perpetual bond.

Raising Capital – The Perpetual Bond

⁴ See the appendix for the technical explanation of this decision rule.

A perpetual bond is a fixed income security with no maturity date⁵. One major drawback to these types of bonds is that they are not redeemable. Given this drawback, the major benefit of them is that they pay a steady stream of interest payments forever. A perpetual bond is also known as a "consol" or a "perp". With perpetual bonds, the agreed-upon period over which interest will be paid is "forever", as perpetual bonds live up to their name and pay interest in perpetuity. In this respect, perpetual bonds function much like dividend-paying stocks or certain preferred securities. Just as the owner of the stock receives a dividend payment as long as the stock is held, the perpetual bond owner receives an interest payment as long as the bond is held. Perpetual bonds have a long history. The British government is often credited with creating the first one back in the 18th century. While they are not anywhere near as popular as the more familiar Treasury bonds and municipal bonds, perpetual bonds continue to be issued today.

Looking ahead, an argument can be made that issuing perpetual bonds would be an attractive proposition for indebted global governments. To fiscal conservatives, the idea of issuing any debt doesn't sound good, and debt that never ends would be positively unfathomable, but perpetual bonds have a certain appeal during troubled times. At its most basic, issuing perpetual bonds would permit a fiscally challenged government to raise money without ever needing to pay it back. Several factors support this approach. The first is that interest rates are extraordinarily low for longer-term debt. The second is that once inflation is factored into the equation, investors are actually losing money on the loans they make to the government. For example, when the interest rate the investors receive is 0.5% and inflation is at 1%, the result is an inflation adjusted interest rate of return for the investors of -0.5%. In dollars and cents, this means that when investors get their money back from the government, its buying power will be diminished. Think of it like this: the investor loaned the government \$100. A year later, the investment's value is \$100.50 courtesy of the 0.5% interest rate. But because inflation is running at 1%, it now takes \$101 to purchase the same basket of goods that cost just \$100 one year ago. Unfortunately, the investors have only \$100.50. The rate of return on their investment failed to keep pace with rising inflation.

Since over time inflation is expected to increase, lending out money today at a hypothetical 4% interest rate will seem like a bargain to government bean counters in the future when inflation hits 5%. Of course, most perpetual bonds are issued with call provisions that permit the issuer to make repayment after a designated period has passed. So the "perpetual" part of

⁵ In 2014, the UK government repaid consols that were first written during the 1700s. "The UK government is to repay part of the nation's first world war debt – 100 years since the start of the war. As Europe marks the centenary of the Great War, the Treasury said it would pay off £218m from a 4% consolidated loan next February, as part of a redemption of bonds stretching as far back as the 18th century. They also relate to the South Sea Bubble crisis of 1720, the Napoleonic and Crimean wars and the Irish potato famine. Almost £2bn of first world war debt remains, and the government said it was looking into the practicalities of repaying it in full. The "4% consols" were issued in 1927 by Winston Churchill, then chancellor, to refinance national war bonds originating from the first world war. The government's Debt Management Office (DMO) estimates that the nation has paid £1.26bn in interest on these bonds since 1927." Source: <https://www.theguardian.com/business/2014/oct/31/uk-first-world-war-bonds-redeemed>

the package is often by choice, rather than by mandate, and can be eliminated should the issuer have the cash on hand to repay the loan.

Perpetual bonds are of interest to investors because they offer steady, predictable sources of income. The payments take place on a set schedule, and some even come with a “step up” feature that increases the interest payment at a predetermined point in the future. In technical terms, this is referred to as a “growing perpetuity”. For example, a perpetual bond may increase its yield by 1% at the end of 10 years. Similarly, it may offer periodic interest rate increases. Paying close attention to any step-up provisions is an important part of comparison shopping for investors looking for perpetual bonds. A growing perpetuity can be good for your pocketbook. A variety of risks are associated with perpetual bonds. Perhaps the most notable is that a perpetual period is a long time to carry on credit risk. As time passes, bond issuers, including both governments and corporations, can get into financial trouble and even fail. Perpetual bonds may also be subject to call risk, which means that the issuer can recall them. Another significant risk associated with time is that general interest rates may rise as the years pass. If rates rise significantly, the interest rate paid by a perpetual bond may be much lower than the prevailing interest rate, meaning investors could earn more money by holding a different bond. In such a scenario, the perpetual bond would need to be sold on the open market, at which time it may be worth less than the purchase price as investors discount their offers based on the interest rate differential.

These types of bonds exist within a small niche of the bond market. This is mainly due to the fact that there are very few entities that are safe enough for investors to invest in a bond where the principal will never be repaid. Some of the notable perpetual bonds in existence are those that were issued by the British Treasury for World War I and the South Sea Bubble of 1720. Some in the U.S. believe it would be more efficient for the government to issue perpetual bonds, which may help it avoid the refinancing costs associated with bond issues that have maturity dates.

Since perpetual bond payments are similar to stock dividend payments, as they both offer some sort of return for an indefinite period of time, it is logical that they would be priced the same way. The price of a perpetual bond is therefore the fixed interest payment, or coupon amount, divided by some constant discount rate, which represents the speed at which money loses value over time (partly due to inflation). The discount rate denominator reduces the real value of the nominally fixed coupon amounts over time, eventually making this value equal zero. As such, perpetual bonds, even though they pay interest forever, can be assigned a finite value, which in turn represents their price. The formula for the present value of a perpetual bond is simply:

$$\text{Present value} = D / r;$$

where D represents the periodic coupon payment of the bond and r represents the discount rate applied to the bond.

Area 3 of Figure 4 represents the presence of an underwriting government agency that shall be remunerated for their services and expertise in the provision of the insurance-style products. The state treasury/debt management agency (TMA) would be a key proposed partner in this regard. The rationale for this proposition is simple, the TMA have a wealth of experience raising large amounts of capital through bond issues, they possess a substantial

portfolio of assets and government wealth that may be useful in the underwriting requirements for any financial produce designed to aid the creation of this education model and finally, they are deemed to be an acceptable financial vehicle under European and international financial rules and regulations albeit that their use is denoted as to provide stabilisation of the banking sector. Due to the forthcoming issues in financing the education system that are being felt in many European countries, the TMA may indeed have a role to play in further economic stabilisation.

In Figure 4, risk areas 4, 5 and 6 are related to broad systematic risk contained within the State economy, but the control of such risk is paramount to a viable probability of success for this finance model. As we have witnessed in the recent economic collapse, unemployment and broad economic conditions will reduce the net payments to the central fund from which this financing system draws upon. Should economic conditions deteriorate during the lifecycle of the system, as one could prudently expect they will, finance will be sourced from bond issuance. During positive economic conditions, this central fund must be replenished to relieve pressure upon the bond refinancing. The bond issuance is used to generate the financing capital to provide financing to those that take part in the scheme within the first twenty years.

Conclusion

The model presented here is a prototype of a new approach to higher education from financial, pedagogical, and philosophical points of view. The objective of presenting this model is twofold: to prepare new graduates for a world where traditional employment will be disrupted by technological advances and to make postsecondary education more affordable and a lifelong process. Moving from the “mortgage model” of education is necessary as the quantity of knowledge rapidly expands and obsolesce rates increase, particularly technology intensive fields. In paying for their own college education students are no longer purchasing a lifetime asset of knowledge and skills for the labour market but a rapid depreciating consumer durable, albeit one that has considerable value in an economy increasingly dedicated to intangibles [30]. By this logic an education can't cost as much as a house, it can only cost as much as a car. The future of education also must take into account the need to learn how to learn. Our model provides the theoretical basis for that process of change and a financial model that sees education as a function effectively of health.

Using an insurance-based model, education can be made cheaper by spreading costs over a large population and a longer time horizon. This bootstraps the risk pooling effects and monopsony effects that such an insurance agency can have on the market for postsecondary education. It also allows education to be understood as something like health care. It is not a once-off non-repeatable investment but a constant investment with elements of incidental out-of-pocket expenses but larger sunk costs being covered by a resource and income pooling instrument.

The advantage of this system is that it combines the risk pooling power of insurance with the growing use of insurance as a minimum-guarantee return financial instrument [31]. It takes one from a position of initial education, to continuing education to the ability to underwrite their retirement in addition to Social Security or reinvest into future generations. It attempts to limit the intergenerational accumulation of wealth with extensive requirements from the wealthy to subsidize the underwriter for opt-outs. Mainly, it provides a tool by which costs

can be controlled and academic mission creep constrained and does so with a basis in a strong pedagogical tradition.

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Appendix: Explaining Financial Options

A knock-in option is a type of barrier option that only comes into existence when the price of the underlying security reaches a specified barrier at any point in time during the option's life. Once a barrier is knocked in, or comes into existence, the option will not cease to exist until the option expires. Knock-in options may be classified as up-and-in or down-and-in. In an up-and-in barrier option, the option only comes into existence if the price of the underlying asset rises above the pre-specified barrier, which is set above the initial asset price. Conversely, a down-and-in barrier option only comes into existence when the underlying asset price moves below a pre-determined barrier that is set below the initial asset price.

Contrary to knock-in barrier options, knock-out barrier options cease to exist if the underlying asset reaches a barrier during the life of the option. Knock-out barrier options may be classified as up-and-out or down-and-out. An up-and-out option ceases to exist when the underlying security moves above a barrier that is set above the initial security price, while a down-and-out option ceases to exist when the underlying asset moves below a barrier that is set below the initial asset price. If an underlying asset reaches the barrier at any time during the option's life, the option is knocked out, or terminated, and will come back into existence.

Barrier options are sometimes accompanied by a *rebate*, which is a payoff to the option holder in case of a barrier event. Rebates can either be paid at the time of the event or at expiration.

- A *discrete barrier* is one for which the barrier event is considered at discrete times, rather than the normal *continuous barrier* case.
- A *Parisian option* is a barrier option where the barrier condition applies only once the price of the underlying instrument has spent at least a given period of time on the wrong side of the barrier.
- A *turbo warrant* is a barrier option namely a knock out call that is initially in the money and with the barrier at the same level as the strike.

Barrier options can have either American, Bermudan or European exercise style.

The student is observed to be purchasing the barrier option to be utilised when the value of their investment has reached a certain threshold, whether it be through their own investment, the aid of a third-party or indeed direct provision of capital through an employer. The funding system is said to be writing the barrier option. It is important to stress that the payments will be same for all participants, however, those entering professions with substantially higher levels of salary will be expected to contribute more through the provision of higher university fees.

The proposed education financing system would mirror that of an up-and-in barrier option. This quite simply refers to a financial product that will provide a payment to students, who would be observed as buying an up-and-in call option on their future level of education. The lifelong learning financing system is said to be writing the option, or providing the up-and-out put option.

Funding for such a system would be proposed to be sourced from exchequer funding, annual insurance payments from students who seek to avail of the education financing system and a perpetual bond guaranteed by the state. In Figure A1, we present a hypothetical system in

which the barrier on a stock price underlier is breached. On the LHS, the underlier is not breached, therefore, there is no payoff. However, on the RHS, the barrier is breached, therefore there is a payoff. It is proposed that the total unit funding for each student should be considered in the same manner to the below underlier, and should it breach a pre-selected barrier level, the student would have the ability to enter the education system while the insurance-style payment system covers their costs.

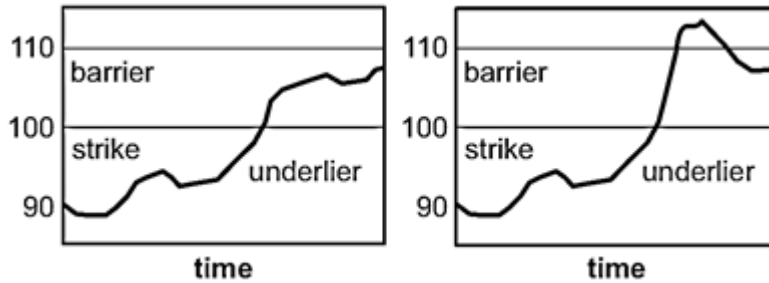


Figure A1: An example of a barrier option being breached

While we review the relationships between the proposed financing system, we can however obtain guidance from the existing relationships between barrier options and underlying financial market products. There are closed-form solutions for pricing European-style barrier options.

A number of different types of barrier options regularly trade in the over-the-counter market. They are attractive to some market participants because they are less expensive than the corresponding regular options. These barrier options can be classified as either knock-out options or knock-in options. A knock-out option ceases to exist when the underlying asset price reaches a certain barrier; a knock-in option comes into existence only when the underlying asset price reaches a barrier. These formulas are best described as:

$$c = S_0 e^{-qT} N(d_1) - K e^{-rT} N(d_2)$$

$$p = K e^{-rT} N(-d_2) - S_0 e^{-qT} N(-d_1)$$

where

$$d_1 = \frac{\ln\left(\frac{S_0}{K}\right) + \left(\frac{r - q + \sigma^2}{2}\right)T}{\sigma\sqrt{T}}$$

$$d_2 = \frac{\ln\left(\frac{S_0}{K}\right) + \left(\frac{r - q - \sigma^2}{2}\right)T}{\sigma\sqrt{T}} = d_1 - \sigma\sqrt{T}$$

An up-and-out call is a regular call option that ceases to exist if the asset price reaches a barrier level, H , that is higher than the current asset price. An up-and-in call is a regular call option that comes into existence only if the barrier is reached. When H is less than or equal to K , the value of the up-and-out call, c_{uo} , is zero and the value of the up-and-in call, c_{ui} , is c . When H is greater than K ,

$$c_{ui} = S_0 N(x_1) e^{-qT} - K e^{-rT} N(x_1 - \sigma\sqrt{T}) - S_0 e^{-qT} \left(\frac{H}{S_0}\right)^{2\lambda} [N(-y) - N(-y_1)] + K e^{-rT} \left(\frac{H}{S_0}\right)^{2\lambda-2} [N(-y + \sigma\sqrt{T}) - N(-y_1 + \sigma\sqrt{T})]$$

and

$$c_{uo} = c - c_{ui}$$

Put barrier options are defined similarly to call barrier options. An up-and-out put is a put option that ceases to exist when a barrier, H , that is greater than the current asset price is reached. An up-and-in put is a put that comes into existence only if the barrier is reached. When the barrier, H , is greater or equal to the strike price, K , their prices are:

$$p_{uo} = -S_0 N(x_1) e^{-qT} + K e^{-rT} N(-y) + K e^{-rT} \left(\frac{H}{S_0}\right)^{2\lambda-2} N(-y_1 + \sigma\sqrt{T})$$

and

$$p_{uo} = p - p_{ui}$$

Barrier options often have quite different properties from regular options. For example, sometimes vega is negative. Consider an up-and-out call option when the asset price is close to the barrier level. As volatility increases, the probability that the barrier will be hit increases. As a result, a volatility increase can cause the price of the barrier option to decrease in these circumstances. One disadvantage of the barrier options we have considered so far is that a “spike” in the asset price can cause the option to be knocked in or out. An alternative structure is a Parisian option, where the asset price has to be above or below the barrier for a period of time for the option to be knocked in or out. For example, a down-and-out Parisian put option with a strike price equal to 90% of the initial asset price and a barrier at 75% of the initial asset price might specify that the option is knocked out if the asset price is below the barrier for 50 days. The confirmation might specify that the 50 days are a “continuous period of 50 days” or “any 50 days during the option’s life.” Parisian options are more difficult to value than regular barrier options.