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Bernard H. Casey [a]
[a] Institute for Employment Research, University of Warwick, UK

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The economic contribution of PhDs

Bernard H. Casey*

Institute for Employment Research, University of Warwick, UK

This paper looks at what the value of a doctorate is, both to employers in particular and to society and the economy at large. Given the emphasis many universities and funding agencies/governments are putting upon the development of PhD programmes, this is an issue deserving attention. The paper tries to show how two separate but interrelated questions 'What is a doctorate worth?' and 'Is there a justification for society to subsidise the production of doctorates?' might be answered. It considers the argument that the production of PhDs can generate benefits for wider society – both because the production process itself generates basic knowledge from which all can take advantage and because the outputs of that process help boost the productivity of those with whom they work. In other words, the gains to society as a whole might be greater than the sum of gains to PhD holders and their immediate employers. Evidence is reviewed.

Keywords: abstract thinking (intelligence); education (government policy); growth theory (endogenous); higher degrees (PhD); returns to education (private and social)

Introduction

Examination of the education process suggests ways in which the production of highly qualified people might raise the abilities of all people. The social dimension of learning might well be important. Moreover, university teachers (who are often PhD holders) might contribute to this process. The production of PhDs can be argued to contribute to a pool of knowledge from which all can draw. PhD holders might also be better at drawing from this pool of knowledge and transferring it into the production of goods and services. Last, clusters of highly qualified people, and of high-technology firms, might generate their own spillovers and members of the cluster might benefit. Again, evidence is reviewed.

The economic contribution of PhDs

This paper comprises an attempt to understand what the value of a doctorate is, both to employers in particular and to society and the economy at large. It seeks to provide some indications of how the two separate, but interrelated questions 'What is a doctorate worth?' and 'Is there a justification for society to subsidise the production of doctorates?' might be answered. The analysis is from an economic perspective. Many of the wider, but largely unquantifiable, benefits (and possibly costs, too) associated with people obtaining and possessing a doctorate are not covered here. However, it will quickly be seen that many of the possible or suggested economic benefits are, themselves, difficult to quantify.

*Email: b.casey@warwick.ac.uk

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The paper is divided into five parts. The first looks at the possible benefits of having a doctorate for the holder of the qualification. It is concerned with whether PhD holders earn more than other degree holders. The second part looks at whether increasing the share of the workforce with a PhD could contribute to an economy's performance. It considers whether the gains from having a highly-qualified workforce include gains going beyond those reaped solely by the holders of degrees and whether the production and use of high levels of knowledge spills over to other firms and to wider society. Part three looks at how the production of PhDs might lead to the generation of knowledge and understanding from which wider society benefits. Arguments for whether there is a justification for public support (including from tax revenue) for PhD production (through the higher education system) are addressed. In the fourth part the way in which the skills of PhD holders, and in which the PhD production process itself, might spill over to firms are examined. Here, the experiences of employers of PhDs are referred to and some thoughts about the role of higher education institutions as hubs from which knowledge is disseminated are given. The last section summarises and draws some conclusions.

Does having a PhD improve earnings?

Much of the discussion of the value of educational qualifications concentrates upon the premium the qualification offers to the individual that possesses it. A subject of much interest has been the 'graduate premium' – the difference over the working lifetime of the earnings of a graduate relative to a person who could have but did not study. Often quoted in the UK is the figure of £160,000 (Universities UK, 2007), although some have cited as much as £400,000 (for example Greenaway & Haynes, 2003). Such figures have been used to justify the introduction of (and increases in the level of) undergraduate tuition fees and the switch from providing students with a grant to giving them access to loans. The size of the graduate premium is considered sufficient to justify the individual investing in the acquisition of a degree. Moreover, the fact that the returns to the investment in the acquisition of the qualification flow primarily to the individual is reason for the state to limit the financial resources it provides. If it were to contribute, it would merely be using revenue collected from all to enhance the earning power of some.

Although much of the analysis has been in terms of first degrees, similar arguments might also be valid for higher degrees. These, too, might enhance earnings. As such, individuals ought to be willing to invest in their acquisition. The role of the state might be limited, as it is with undergraduates, to overcoming the market failure that limits those wishing to study and who have no collateral other than future human capital against which they can borrow to raise the necessary investment.

The most up-to-date estimates of the premiums associated with university study in the UK indicate that, on average, it is positive and substantial (O'Leary & Sloane, 2005). Male holders of a Bachelor's degree enjoy an earnings level that is over 20 per cent higher than men who could have studied but chose not to, whilst women who studied earn over 35 per cent more than an equivalent comparator. Moreover, studying further brings further returns. Men with a Master's degree earn 29 per cent more than the base, women with a Master's, 55 per cent more. Obtaining a PhD raises the gap yet further – to 31 per cent for men and 60 per cent for women.

On the other hand, it is also apparent that declining returns set in. The difference for men between the Master's and PhD premium is small; the difference for women is not large. Moreover, in the same way that the returns for a first degree are, on average, high

Table 1. Earnings premia by type of level of degree, discipline and sex.

	Men			Women		
	BA/BSc	MA/MSc	PhD	BA/BSc	MA/MSc	PhD
Medicine and related	20	20	38	41	49	55
Sciences	12	12	20	22	30	36
Maths and computing	28	28	28	34	49	47
Engineering and technology	25	33	25	32	48	32
Architecture and related	16	30	16	36	36	*
Social sciences	14	22	22	28	46	42
Business and financial studies	24	38	44	35	54	46
Arts	–3	6	–3	19	27	28
Languages	7	7	7	19	19	19
Education	18	30	18	42	49	54
Combined	14	23	26	23	38	38

Source: own calculations from O'Leary and Sloane (2005), Tables 4, 5, 9 and 10. Only premia that are significant at a minimum of 90 per cent confidence level are taken into account.

Notes: The earnings premia show the per cent by which the holder of a qualification earns more than a person who had the basic qualifications to attend university (two A-levels) but who chose not to. The Table is to be read as follows: a woman obtaining a Bachelor's degree in maths and computing receives a premium of 34 per cent. If she also has Master's degree, she earns 49 per cent more, but if she has a PhD (irrespective of whether she has a Master's degree), she earns only 47 per cent more; *insufficient data available to calculate a premium.

but are also subject to considerable variance, so, too, the returns to a PhD are very different depending upon the subject studied. This is illustrated in Table 1.

Basic economic theory teaches that wages reflect marginal productivity. The implication of Table 1, on this basis, is that taking a higher degree enhances the productivity of women more than it does of men, but that PhDs in medicine, sciences and business and finance and (for men only) engineering, substantially enhance productivity. PhDs in social sciences, languages and arts do not enhance earnings significantly for either sex. It might, of course, be the case that 'among graduates with good degrees the characteristics that incline someone to go into postgraduate work may well be the ones which would make that person less attractive to a potential non-academic employer [so that] someone who goes on to postgraduate study . . . improves his own employability and likely income even though these remain below the employability and likely income of those good graduates who have no wish to go on to postgraduate study' (the 1982 Swinnerton-Dyer Committee on Postgraduate Education quoted in Rudd, 1987, p. 238).

On top of this, it must be recognised that wages do not always reflect marginal productivity. PhDs in social sciences, arts, languages and education are disproportionately employed in the education sectors and, in particular, in the higher education sector. For example, in the UK nearly four-in-ten PhDs are employed in worker education, primary, secondary or tertiary. Earnings here are rarely determined solely by market forces but rather by government-imposed financing rules. Of course, employers in education might argue that they offer higher non-monetary benefits, such as a high level of task autonomy, that compensate, at least in part, for the low level of the monetary reward they receive. Nevertheless, the relatively low earnings of university, further education and school teachers, which are the principal sources of employment of PhD holders, might also encourage employers outside the education sector to feel confident in being able to offer holders of such degrees relatively low wages. The highest mark-ups for PhDs are in sectors more open to market forces.

Does the production of PhDs improve economic performance?

Whether or not having a PhD enhances earnings, indicators of earnings enhancement are measures of private returns from the possession of a qualification. They are not an argument for public support for PhD production. For such an argument to be valid, some positive social returns have to be visible. In this respect it is insufficient to argue that a more highly qualified labour force contributes to economic growth. Standard growth models, even if they include 'augmented labour', by which is frequently meant tertiary-level qualified labour, are normally predicated upon factors receiving the marginal return to their input. In the case of labour, this marginal return is equal to the wage. Augmented labour receives a higher wage. This is illustrated in the Appendix, Equations 1 and 2.

Arguments for public support have to be able to show that, somehow, higher degrees are a 'public good'. The public good that is the concern here is that PhDs enhance not merely the productivity of the individuals who posses them, but also the productivity of society as a whole. The fact that society as a whole benefits from this public good could mean that private initiative fails to produce adequate output. This is because any one individual – a person or a firm – who sponsored the production of a higher degree would find the benefits of his/her/the firm's investment enjoyed by other individuals who were able to 'free-ride'.

The nature of the public good falls into two parts. First, the production of PhDs is an integral part of the production of basic research – itself a public good from which all benefit. Second, the holders of PhDs, when they are employed, generate production externalities – in other words, their having a PhD raises not only their own productivity but also productivity of those without a PhD alongside whom they work. A third externality, such as that consequential upon PhD holders enhancing the social milieu or producing 'better' children, is (yet) more difficult to measure and is not discussed here.

With respect to the standard growth model, the state of technology is assumed to be exogenously determined. It can increase – and some analysts suggest it does – gradually and over time. This is illustrated in Equation 3 of the Appendix. Nevertheless, in this model, and those growth models derived from it, technical progress is given like 'manna from heaven' – the determinants of the size of μ is unexplained. On the other hand, there are growth models that see technical progress as endogenous. They see it as being enhanced by education, regardless of how that education is provided. If education can enhance growth through its impact on society as a whole, there is an argument for society as a whole to sponsor it.

If there were spillovers from PhD production, these might be because the presence of PhDs in the labour force enhances the productivity either of all workers or of workers within the firm in which they are employed. Equations 4 and 5 of the Appendix show how this can have an impact on the output of a single firm and, by analogy, on the economy as a whole.

Attempts to test whether endogenous growth models explain economic performance better than neoclassical growth models have not come to conclusive answers (see, for example, Gemmell, 1997; Luintel & Khan, 2005; Pack, 1994). In summary, and at least with respect to OECD countries, it seems as if:

> Time spent by people in higher education might be more important than time spent in secondary education in explaining one country's performance relative to that of another.
>
> Countries that produce a higher proportion of science and engineering graduates seem to experience larger increases in productivity than countries that merely produce graduates in general.

> Countries that perform better seem to be as much those where the initial level of education was high as those where the level of education was improved.
> Within any one country, productivity appears to rise as the proportion of the labour force with higher education increases.

However, these results are not conclusive to suggestions that endogenous growth models are superior, since they are not inconsistent with the propositions of neo-classical growth models.

Nevertheless, endogenous growth theory does indicate some of the ways in which a highly qualified labour force might provide benefits. Accordingly, its production might warrant public financing. The argument here revolves around the production of understanding and knowledge and its transmission and application into the production of goods and services.

What is the role of PhD production in the generation of knowledge and understanding?

Education might have a role in generating the externalities upon whose existence the validity of endogenous growth theory relies. It might contribute to the provision of the public good of knowledge that can be embodied in human and physical capital. In short, better people produce better ideas and better ideas produce better machines and better ways to use them. Moreover, there might even be inter-temporal spillovers, so that the current pool of ideas benefits not only existing people, in that it enhances their productivity, but also future generations.

One of the important justifications for the provision of tertiary level education is that such education develops the ability to think abstractly. The ability to think abstractly brings rewards to the individual – especially access to better paid managerial and professional positions – and it is for this reason that the individual undertakes higher education. Nevertheless, the wish of the individual to develop his/her ability to think abstractly might have a spillover effect in that it also induces others to develop their ability to think abstractly.

However, if higher education had no impact on the ability of the individual to think abstractly, but merely correlated with such ability or was thought to correlate with such ability, the individual who undertook higher education would merely improve his/her position in the queue for better-rewarded jobs. In such a case, there would be no argument for subsidising higher education. It would only be worth subsidising it if it proved an efficient screening device, thus reducing poor job matches, raising individual productivity and reducing unemployment. Similarly, if higher education improved the ability to think abstractly, but all the rewards from being able to think abstractly flowed back only to the individual who had undertaken it, there would be no argument for subsidising it. It is only if spillovers exist that subsidy is justified.

One of the possible spillovers is the social dimension of learning. In order to maximise the rewards available to those with higher education, it is necessary not merely to undertake such education but to excel in it. The individual wishes to excel, but this requires that all others undertaking such education also strive to excel. If, by trying to excel, the individual increases his/her ability to think abstractly, he/she will be more likely to obtain the rewards of having done so. As important, however, is the fact that he/she will also encourage others to try to excel. To the extent that all improve their ability to think abstractly, the individual has to engage yet more intensively. This process has been

described as one involving 'reciprocal causality' or 'cascading feedback loops' or the operation of the 'social multiplier' (see Flynn, 2007). More simply, it might be thought of as an hydraulic effect.

The production of higher degrees might contribute to the operation of this hydraulic effect and it might do so in two ways. First, working for a higher degree involves individuals striving to excel and their striving to excel induces other to strive to excel. Second, holders of PhDs go on to become inputs into the education process. They form part of the environment in which striving to excel occurs and they facilitate that process. To the extent that society benefits from the spillovers of the mass of individuals striving to excel, there might be an argument for society (in the form of the tax payer) supporting the production of those who facilitate such striving to excel. In other words, there might be an argument for society to subsidise the production of university teachers – PhDs. Moreover, given the low earnings premia associated with jobs in (higher) education without such a subsidy, the supply of facilitators of the process of striving to excel (teachers/lecturers) might be suboptimal. This suboptimal supply might express itself quantitatively or qualitatively.

How do spillovers occur?

It is argued that an increasing share of jobs require their holders to be able to respond to and deal with hypothetical issues, with issues that are not fully anticipated and with issues where one cannot simply respond according to prescription or pre-established guidance systems. In short, they require their holders to find 'on the spot solutions' (Flynn, 2007). The possession of a PhD, as much as the possession of a Bachelor's degree, might serve as an indicator of the extent of a person's innovativeness and independence and so of the contribution he/she might make. Thus, a recent UK study of employers (Jackson, 2007) reported that:

> PhD researchers were seen by many . . . to possess skills and competencies that are hard to find among new graduates. . . . [Recruiters] describe PhD graduates as 'being able to hit the ground running'. This can manifest itself in a variety of ways, such as PhD graduates' familiarity with specialist techniques and equipment, their ability to review and précis reports or in the structured way they approach solving complex problems. (p. 29)

This suggests that employers might be putting a higher value on the contribution a PhD training brings than do PhD holders themselves.

The qualities possessed by PhDs are important for firms that are competing in the market place and wish to maintain and improve upon their position relative to other firms. One way in which firms can do this is to ensure that they are both open to new ideas and can use these ideas. Firms that employ highly qualified staff might be able to 'hoover up' and transform or imitate new technologies and ideas faster than firms that do not, whilst their highly qualified staff can communicate how these ideas should be used to those with whom they work faster than those without such qualifications. Firms with highly qualified staff profit from the wider environment in which they operate and the way in which the highly productive, highly qualified staff improve the productivity of those less qualified staff with whom they work (see Gemmell, 1997; Lucas, 2008).

The study of employers of PhDs referred to earlier (Jackson, 2007) captures some of the second part of this argument when it reported:

> A critical skill in many settings was the ability [of PhDs] to communicate effectively with non-specialists. This was just as true for [employers] recruiting people for their specialist

> knowledge as for those looking for more generic skills. Several of the employers . . . stressed the importance of being able to explain complex information or specialised research findings to non-specialists as a critical skill. (p. 29)

By way of contrast, another study of employers has one of these saying of early career researchers that these 'do not appear to articulate their personal skills well and seem to be unable to talk to employers in "their" language' (Morgavi, McCarthy, & Metcalfe, 2007, p. 6).

To the extent that firms profit from having staff who are good at acquiring ideas and good at mediating these ideas to other members of staff, they might be expected to reward the relevant staff accordingly (Lucas, 2008). This would explain the somewhat higher earnings of science and (female only) engineering graduates illustrated in Table 1. On the other hand, Table 1 hardly presents convincing evidence that, if there are intra-firm externalities, it is PhD scientists, engineers and technologists, as opposed to bachelor- and master-degree holdings scientists, engineers and technologists, who contribute to their realisation.

The pool of ideas from which the highly qualified staff are drawing might be part of the public good of basic research that has been sponsored by wider society. On the other hand, firms might be drawing from a pool of ideas that have been generated by other firms and that have not been fully patented. Even when ideas are patented, there is usually some limited spillover. That ideas are the product of private initiative does not prevent them from spilling over. Successful science parks might be agglomerations of private businesses clustering together because these businesses recognise that some ideas will spillover (Lucas, 2008). There are, of course oft-cited cases of higher education institutions having an important role in initiating successful science parks (for example, Silicon Valley and Route 128), but not all science parks are a success and not all science parks arise with the active involvement of a local higher education institutions (for example, the Thames Valley/M4 corridor) (see, for example, Lawton Smith, 2007). Equally, there are examples of spillovers from local higher education institutions to local businesses, but there is no reason why a particular institution should feed only local businesses and, indeed, the most successful ones might feed national or even international businesses (Gemmell, 1997).

There is, however, some evidence to the contrary that suggests spillovers might exist. For example, a study of workers in the UK (Battu, Belfield, & Sloane, 2003) found that working with colleagues who each have 1.2 years (1 standard deviation) more education than the average worker boosts own earnings by 11 per cent. More pertinent, since it specifically referred to higher education, an area-level study of earnings in the USA (Moretti, 2004), found that a 1 per cent increase in the labour force share of college graduates in a city drove up wages by 1.9 per cent for labour force participants without a high school diploma, by 1.6 per cent for labour force participants with a high school diploma and by 0.4 per cent for college graduates. Unfortunately, studies that consider not merely education in general, or higher education in particular, but the impact of PhDs in a firm or an area are, as yet, lacking.

Summary and conclusions

PhD holders are not an homogenous group. They are used in different ways and they are rewarded differently. From an individual point of view, it would not always seem that acquiring a PhD improves a person's earning capacity. Women appear to improve their earning power more than do men, but the ability to earn more depends heavily upon the subject studied. Some explanation for this might lie in the way in which a substantial proportion of PhD holders are employed in the (higher) education sector.

There are arguments that the production of PhDs generates benefits for wider society. The production process helps generate basic knowledge from which all can take advantage, whilst the outputs help boost the productivity of those with whom they work. The gains to society as a whole are greater than the sum of gains to PhD holders and their immediate employers. 'Endogenous growth theory' has an appeal, although successful attempts to find empirical validation for it are relatively rare. This does not mean its propositions should be dismissed.

Examination of the education process indicates ways in which the production of highly qualified people raises the abilities of all people. The social dimension of learning might well be important. Moreover, university teachers (who are often PhD holders) might contribute to this process. This might provide an argument for the state subsidising the production of PhDs. Certainly, it does not appear as if such subsidisation assists the ability of PhD holders to improve their own earnings.

The production of PhDs can be argued to contribute to a pool of knowledge from which all can draw. PhD holders might also be better at drawing from this pool of knowledge and transferring it into the production of goods and services. Clusters of highly qualified people, and of high-technology firms, might generate their own spillovers and members of the cluster might benefit. However, this is not, per se, an argument for public support, since some clusters exist independently of government support and/or without a higher education institute at their hub.

That spillovers do occur, and that PhDs can contribute to the acquisition and transfer of knowledge, is difficult to dispute. How spillovers occur, and how they can be quantified, is much less clear. In this, there is scope for further research.

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Appendix 1. Production functions incorporating augmented labour, technological change and spillovers

A simple production function with augmented labour:

$$Y = AK^{\alpha}L^{\beta}H^{\gamma} \tag{1}$$

where Y is output, A is total factor productivity or technical knowledge, K is capital, L is non-augmented labour and H is augmented labour and where the marginal products of factors – α, β and γ – sum to unity.

If PhDs were to be considered in their own right the model would be:

$$Y = AK^{\alpha}L^{\beta}H^{\gamma}P^{\varepsilon} \tag{2}$$

where P is super-augmented labour (PhD holders), ε is the marginal product of this labour and where, again, all the marginal products – α to ε – sum to unity.

Explanation for non-technical readers

These equations state that output is driven by a combination of the state of technical knowledge, the amount of capital (machines), labour (workers) and 'augmented' labour (usually taken to be tertiary qualified workers) employed. Capital and labour (including augmented labour) are rewarded by interest and wages, respectively. The interest rate and the wage rate are set in competitive markets.

A production function with increasing technical progress:

$$Y = Ae^{\mu t}K^{\alpha}L^{1-\alpha} \tag{3}$$

where $e^{\mu t}$ represents the exogenous determined rate at which that technology evolves over time.

Explanation for non-technical readers

The term $Ae^{\mu t}$ shows the rate of growth of the state of technology. The growth rate is continuous over time (the t term), but the rate of growth is also determined by the size of the μ term.

A production function for a single firm showing spillovers:

$$Y_j = AK_j^{\alpha}L_j^{1-\alpha}L_a^{\delta} \tag{4}$$

where the subscript j refers to the individual firm, L_j to the level of human capital in the firm, L_a to the average level of human capital across all firms and δ is the externality effect upon output for all firms. Output for all society would be the sum of all the n individual Ys ($\sum K_1^n$). The L_a^{δ} term can be said to be the term that influences the value of the parameter μ in the previous equation. (Note that, if there are no external effects at all, δ equals 0 and so H_a^{δ} equals 1.) The L terms themselves could be taken to be determined by the share of highly qualified workers in the firm and the economy.

A more sophisticated version of the same model:

$$Y_j = AK_j^{\alpha}L_j^{1-\alpha}(H_j/N_j)_j^{\delta}(H/N)^{\delta} \tag{5}$$

which decomposes the effect into the intra-firm externality – the impact of the share of workers with augmented capital relative to all workers within the firm (H_j/N_j) or the positive influence highly qualified workers have on their colleagues – and the inter-firm externality – the impact of the share of highly-qualified workers in the economy as a whole (H/N) on all firms in the economy.