# Higher education: a risk too far

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The protagonists of Great Britain's Industrial Revolution were, famously, typically men without a formal education. Nevertheless, the development of ultrahigh technologies such as nanotechnology seems to demand a high level of higher education. This essay appraises the appropriate level of graduate education using the concept of the J-value. Education is discussed in the context of other government services. It is concluded that higher education is an excellent national investment provided the number of graduates is maintained at an affordable level.

## 1. Introduction

Higher education in the UK since the election of the Coalition government in 2010 has generated considerable unrest in the student population, and been characterized by a difficult time for the Liberal Democrat politicians, not least because of their *volte face* over tuition fees. The fact that Scotland continues not to charge tuition fees further exacerbates the unease felt by the UK government.

The justification for charging tuition fees is that the government seeks to reduce the financial burden of higher education from about £9 billion in 2011 to £4.2 billion by 2015,[1] achieved by raising tuition fees from £3000 a year to what was supposed to be a maximum of £9000 per year, but which has subsequently turned into the average, being the amount charged by most universities.[2] One might ask, as have the students, why?

Considered as an investment in the future made by government for the benefit of the state, education, particularly higher education must be one of the best returns on investment that can be made. A 2004 report by PricewaterhouseCoopers[3] estimated that the average cost of producing a graduate was about £21,000 but that once graduated, especially in medicine, law or the sciences, the graduate would earn 30% or more per hour than an individual leaving school with two

[1] Throughout this article, "billion" (bn) denotes the U.S. billion, i.e. $10^9$.

[2] Universities face cut in spending to £4.2 bn, by Chris Cook, Education Correspondent of the *Financial Times*. Published: 20 October 2010 http://www.ft.com/cms/s/0/be4b7c70-dc4b-11df-a9a4-00144feabdc0.html. Universities will be forced to raise fees to offset a cut in subsidies, allowing the government to cut direct spending on higher education from £7200 million to £4200 million by 2014–5.

[3] *The Economic Benefits of Higher Education Qualifications*. A report produced for The Royal Society of Chemistry and the Institute of Physics. PricewaterhouseCoopers (January 2005).

*Nanotechnology Perceptions* **8** (2012) 139–147
*Received* 18 June 2011

'A' levels (Figure 1). As a consequence, the *return through taxation* was typically £93,000 over a working lifetime. Moreover, gross domestic product (GDP) is also a beneficiary as innovative graduates typically work in or form companies that generate wealth (here it is tacitly (but naïvely) assumed that innovative wealth generation can expand indefinitely, being solely assumed to depend on the number of graduates, without even, apparently, regard to their subject of study).

Percentage hourly earnings premium associated with different degree level subjects (21–60 year olds) compared to 2 or more 'A' levels: Labour Force Surveys 2000–2004 pooled

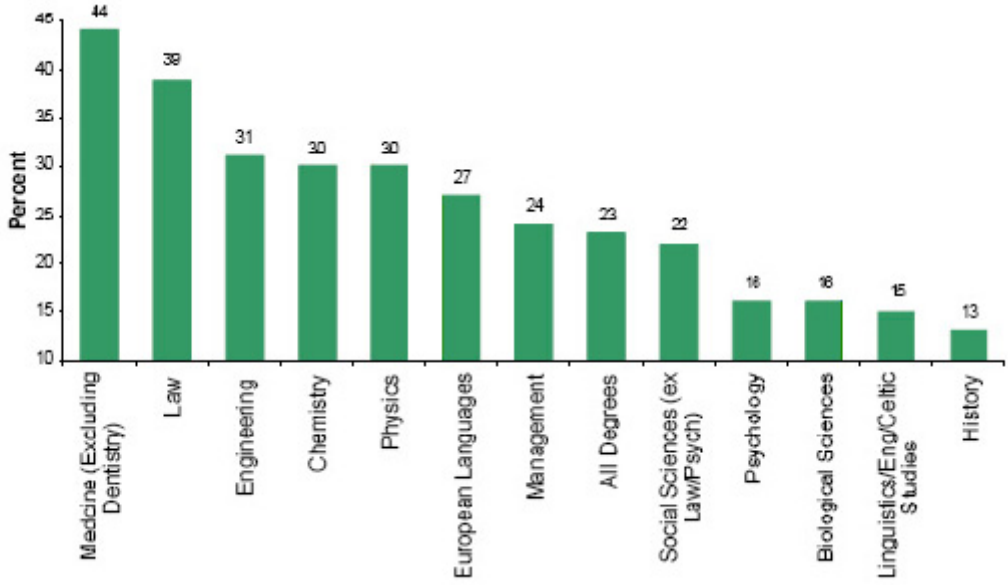


Figure 1. Graduate earnings.[3]

To an accountant this must sound like manna from heaven and was perhaps the reason why the last Labour government encouraged a much larger graduate population, as much as 50% of the eligible cohorts. Typical of the social engineering practised by politicians was, however, the failure to recognize the ramifications: 'A' levels became easier in order to encourage students to reach the entry criteria, as a consequence universities found themselves spending more time with the students before they reached an adequate level to start a degree course and in some cases degree standards dropped while in others universities were accused of social bias by not accepting more students from socially deprived backgrounds, in which, it was assumed, the levels of educational attainment were lower. Another consequence has been a change in the courses studied over the last 15 years or so (Figure 2). Overall, there seems to have been a decline in at least the perception of the value of a degree, if not the reality as well. More recently, even the value of postgraduate qualifications like the PhD are being brought into question.[4]

[4] A. McCook, Education: Rethinking PhDs. *Nature* **472** (2011) 280–282. "Fix it, overhaul it or skip it completely—institutions and individuals are taking innovative approaches to postgraduate science training. 'Most of them are not going to make it.'—that was the thought that ran through Animesh

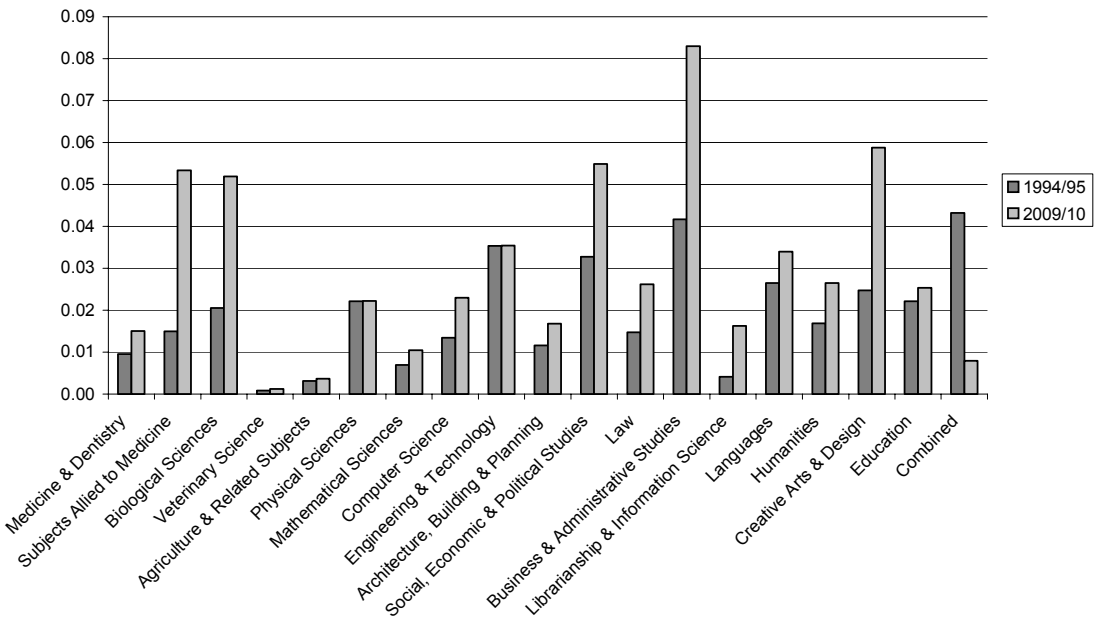


Figure 2. % of the population of UK obtaining first degree by subject.[5]

As might be expected with the rise in internet usage, information technology courses are now more popular, with many more graduates in this field and in law and medicine. These increases in number may reflect the rising wages associated with those professions and that the choices made by students are, ultimately, to seek the greatest monetary rewards. Certainly the recent increases in general practitioner's salaries and society's predilection for litigation may explain the popularity of medicine and law. Another possible explanation for the large increase in medicine-related studies is that it reflects an increasing preoccupation with aging and the pharmaceuticals being developed to counter it. The increase in graduates in social sciences such as media studies may well reflect the status of some of the newer universities offering less demanding academic courses: the 1992 Education Act gave the polytechnics and establishments like the Cranfield Institute of Technology university status and almost doubled the number of UK universities.[6]

Ray's mind 15 years ago, as he watched excellent PhD students—including some at his own institution, the University of Rochester in New York—struggle to find faculty positions in academia, the only jobs they had ever been trained for. Some were destined for perpetual postdoctoral fellowships; others would leave science altogether."

[5] Derived from The Higher Education Statistics Agency (HESA) http://www.hesa.ac.uk/index.php/content/view/1973/239/ Table 14a—Qualifications Obtained in the United Kingdom by Mode of Study, Domicile, Gender and Subject Area 1994/95 and Table 16—HE qualifications obtained by subject of study, level of qualification and class of first degree 2009/10.

[6] The passage of the Further and Higher Education Act 1992 allowed all polytechnics to become universities. 38 took up the offer immediately, nearly doubling the number of universities from 46 to 84.

Perhaps the only success of the last Labour government was that the university population has indeed increased by about 50% since 1994, but at what cost? The recession in the UK and the increased population of students has meant that government can no longer afford free university education, even if the returns are high, and students are now advised to "pay more to get more".[7]

Perhaps the most important factor in this is human nature itself. Not all young people of university education age are intellectually able to achieve a good degree. It was sheer arrogance of politicians to assume that it would be possible and that the numbers would increase without standards dropping. Marxism is a prime example where social engineering failed because political ideology ignored human nature and the fact that corruption, avarice and sloth are endemic. There is almost certainly some threshold percentage of the population that is capable of achieving high academic standards. The actual percentage can be debated,[8] but it is probably significantly lower than the aspiration of the last government. This may sound like élitism but, rather, reflects the true nature of the human condition.

A critic of the Coalition government, or at least the Conservative part of it, might be forgiven for hoping that the raising of tuition fees, apart from solving the immediate fiscal problem, will also discourage students from university education unless they are both academically able and focused. The net result might be a return to higher standards and a sustainable population of higher education students biased more towards those subjects that offer greater long-term salaries and growth for the economy. At this sustainable level it may even be possible to abandon tuition fees again.

The aim of this paper is to look at a more scientific way of assessing what government can afford as an investment in higher education, not driven by financial probity but by a genuine desire to invest in the future of the state and the quality of life of its citizens.

## 2. The J-value approach

The advent of electricity generated by nuclear fission gave rise to a more scientific method than hitherto to assess the risks of a nuclear accident. There was a need to understand benefit in the cost of providing safety measures. To this end, an approach using the *life quality index* was developed by Thomas and others.[9]

The starting premiss was that life quality is a function of leisure time and wealth (see the Appendix). For the nuclear industry, the two most important parameters were cost and how much life would be shortened by a nuclear accident, so that a primitive life quality index $Q^*$ was made to be a function of average life expectancy $X$ and GDP per capita $G$, which represented wealth:

$$Q^* = G^q X. \quad (1)$$

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[7] Lord Browne, Securing a Sustainable Future for Higher Education. An Independent Review of Higher Education Funding & Student Finance. Published 12 October 2010, http://www.bis.gov.uk/assets/biscore/corporate/docs/s/10-1208es-securing-sustainable-higher-education-browne-report-summary.pdf

[8] See the estimate of Sir Lawrence Bragg, Physicists after the war, *Nature* (Lond.) **150** (1942) 75–80.

[9] P.J. Thomas, D.W. Stupples and M.A. Alghaffar, The extent of regulatory consensus on health and safety expenditure. Part 1: Development of the J-value technique and evaluation of regulators' recommendations, *Trans IChemE, Part B; Process Safety and Environmental Protection* **84(B5)** (2006) 329–336.

After some manipulation by perturbation it is possible to derive the maximum cost for a given life extension based on GDP, the number of individuals affected $N$ and the ratio of working time $w$ to leisure time during the duration of a life.[10]

To examine the benefits of higher education, the life quality index adopted by Thomas et al. needs to be extended to include more quality of life features. Most people would agree that having an income above the average provides them with more freedom and, by implication, a better quality of life, and this is precisely the attraction of graduation for many students.

Thus, we can define a modified (extended) life quality index as

$$Q = G^q X (E_g/E)^p \tag{2}$$

where $E$ is average earnings and $E_g$ the salary of a graduate, while $p$ is a parameter to be defined but initially set to unity. Perturbation of equation (2) yields the following:

$$\Delta Q/Q = q\,\Delta G/G + \Delta X/X + p\,\Delta(E_g/E)/(E_g/E) \tag{3}$$

and if overall life quality is not to change, although the increase in graduate income is at a cost of the nation's wealth in GDP per capita (i.e., $\Delta G$ is negative), then, for no loss of life quality:

$$\Delta G \leqslant N p/q\, G\, \Delta(E_g/E)/(E_g/E) \tag{4}$$

where $N$ is the number of benefiting graduates. This inequality gives the total maximum cost to the state assuming there is no change $\Delta X$ in lifespan. Although increased earnings might be considered advantageous through the affordability of increased healthcare and thus life expectancy, there is no evidence for such an effect by income groups;[11] consequently $\Delta X$ is set to zero. Equation (4) thus indicates the maximum that a state can afford to pay to improve the lot of graduates, and the J-value provides a measure of the actual spend $S_{HE}$ as a ratio with respect to the maximum:

$$J = S_{HE} / \Delta G_{max}\,. \tag{5}$$

A J-value greater than unity represents overspend for the benefit gained.

Finance data from the Higher Education Statistics Agency (HESA) show that in 2009/10 funding body grants amounted to just over £9 million for a student population of some 2.5 million, whereas in 1994/5 this was under half at £4.4 million for a student population of 1.6 million.[12] The values of the other parameters to calculate the J-value and the J-values themselves for the years 1994/5 and 2009/10 are shown in Table 1.

Note that the value of money in the UK has almost halved over the 15 year period, but the J-value is calculated at the rates current at the time, and is thus independent of inflation.

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[10] The slightly different *quality of life index* is assessed more subjectively using many factors, including GDP and lifespan but also other parameters such as health care, care for the elderly, stability of government, lawlessness and general wellbeing. An annual league table of nations with the best quality of life is published and often the wealthiest nations are not the leaders. See: *International Living 2010* http://internationalliving.com/2010/02/quality-of-life-2010/. To produce this annual quality of life index nine categories: Cost of Living, Culture and Leisure, Economy, Environment, Freedom, Health, Infrastructure, Safety and Risk, and Climate are considered. For the fifth year running, France has taken first place!

[11] G.B. Rodgers, Income and inequality as determinants of mortality, *Int. J. Epidemiology* **31** (2002) 533–538.

[12] HESA finance data (April 2010) http://www.hesa.ac.uk/index.php?option=com_content&task=view&id=1675&Itemid=161

Table 1. J-value parameters (see Appendix for derivation).

| Year | $a$ | $b$ | $\Delta T$ | $E_g/E$ | $w$ | $q$ | $p$ | max $\Delta G$ /£m | $G$ /£ capita$^{-1}$ | $S_{HE}$ spent /£m | $J$ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2009/10 | 0.047 | 0.04 | 35 | 1.3 | 0.117 | 0.132 | 1 | 99037 | 234454 | 9043 | 0.09 |
| 1994/5 | 0.047 | 0.04 | 35 | 1.3 | 0.117 | 0.132 | 1 | 32639 | 119765 | 4395 | 0.13 |

As might be expected, the J-value for 2009/10 has decreased significantly. Commentators have already noted that the UK is falling behind other countries in higher education spending,[13] and it would seem that apart from raising money via tuition fees the only alternative for the UK if it wishes to regain its higher education status would be to fairly drastically reduce graduate numbers (Figure 3). Note to achieve a near-unity J-value of 0.91 the student population would have to be multiply decimated to just under 250,000.

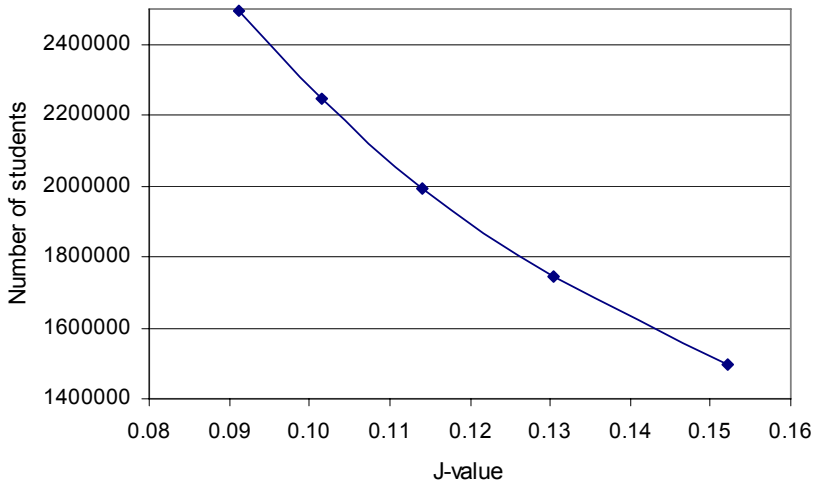


Figure 3. HE population versus J-value.

## 3. Discussion: the role of government

In using the J-value approach to assess the risk to the status of higher education in the UK, the concept of life quality has been used. This in itself raises the question whether government is ultimately responsible for life quality.

Most people would find it unexceptionable that government is in place to pass laws and police the state in order to achieve and maintain stability. Similarly, defence and the

[13] *Times Higher Education*, UK lags behind in spending, 17 September 2004. "Spending per higher education student grew 8 per cent in the UK in real terms between 1995 and 2001, compared with an average of 30 per cent across other Organisation for Economic Cooperation and Development countries. UK spending on higher education as a proportion of gross domestic product remained below the OECD mean in 2001, falling behind the US, Canada, Denmark, Finland, the Netherlands, Sweden, Australia, Ireland and Korea. The share of higher education funding ploughed into capital expenditure in the UK is, at 2.3%, among the lowest in the OECD, and compares unfavourably with an 11.5 per cent average." http://www.timeshighereducation.co.uk/story.asp?storyCode=191234&sectioncode=26

maintenance of the fundamental infrastructure of the state are also necessary functions of government, but should the effectiveness of government actually be judged by the quality of life (or life quality) index? Obviously government will have almost no influence over climate, at least in the short-term, but perhaps the major parameters that should be of concern as influencing the index are GDP and life expectancy. That is, government should promote economic growth and longer life as priorities.

Both of these parameters present the human race rather than individual nation states with a dilemma. Arguably the problem of climate change is due to the rapid rise in human population over the last few centuries. Population stability is essential if we are to have a sustainable planet.[14] Economic growth is as problematical as population growth since it is achieved through the exploitation of underdeveloped countries in many instances, or through advertising and the attempt to persuade consumers to purchase the unnecessary. *No economic growth* was advocated in the early 1970s, based on the results of global modelling,[15] but was not popular, not least because the models ignored human nature and politics. Indeed F.A. Hayek, one of Margaret Thatcher's economic gurus, suggested that free market forces should dominate and government should *only* concern itself with laws and policing.[16]

So what should government do? So far Western governments have ignored antiglobalization calls and pursued economic growth while extending life expectancy through better healthcare (an objective pursued more avidly by some states than others) but, although seemingly rarely considered in such terms, education must be one of the best investments a Government can make in the future of the state to ensure prosperity, in the sense of providing services and goods that are particular to the skill sets and resources of the country—and prosperity is a prerequisite for being able to afford healthcare.

Fortunately, the UK Government has little control over higher education other than through the award of grants, unlike secondary education where intrusive micromanagement by politicians has blighted educational standards. One can only hope that the universities, by seeking the maximum allowable tuition fees, will effectively regulate and bring the graduate population down to a sustainable percentage of the eligible population, reflecting the ability of the students to pass high entrance thresholds, so that merit rather than political social interference sets the standards. That is not to say that more of the population should not be educated to a higher standard but that for the majority it should be geared more toward business and vocational training with qualifications separate from those of universities. Individuals following such a régime may well contribute more to the economy than at present—but now technology is still dominated by the larger companies employing lots of graduates and on this basis the low J-value rightly indicates the poor choice made by the previous Labour government in trying just to increase graduate numbers without looking at the consequences.

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[14] J.J. Ramsden, What is sustainability? *Nanotechnol. Perceptions* **6** (2010) 179–195.

[15] D.H. Meadows, D.L. Meadows, J. Randers and W.W. Behrens III, *The Limits to Growth*, Universe Books; 2nd edn (18 February 1974).

[16] J. Ranelagh, *Thatcher's People: An Insider's Account of the Politics, the Power, and the Personalities*, p. ix (Fontana, 1992). It was F.A. Hayek's *The Constitution of Liberty* (1960) that Thatcher banged down on the table at the Conservative Research Department in 1975 saying "This is what we believe".

## Appendix

To recapitulate, for the nuclear industry, the two most important parameters are cost and how much life was shortened by a nuclear accident, so that the life quality index $Q$ was made to be a function of average life expectancy $X$ and gross domestic product (GDP), which represents wealth per capita ($G$) and leisure time $L$:

$$Q = G^q L \tag{A1}$$

where $q$ is a parameter to be defined. It is reasonable to assume that

$$G = G_0 w X \tag{A2}$$

where $G_0$ is the actual national average and

$$L = (1 - w) X, \tag{A3}$$

where $w$ is the ratio of working time to life time $X$. Then,

$$Q = G_0^q w^q (1 - w) X^{q+1} , \tag{A4}$$

which after differentiation with respect to $w$, assuming $q$ and $X$ are independent, gives a maximum when

$$q = w/(1 - w) . \tag{A5}$$

Now the ratio $w$ is most easily estimated by assuming for hard-working graduates a 9 hour day working 5 days a week for 35 years of a life expectancy of 80 years, giving

$$w = 9/24 \times 5/7 \times 35/80 = 0.117 . \tag{A6}$$

Thomas et al.[9, 17] deduced a similar number by looking at average working practices and including sickness, hence this will suffice and gives a robust value for $q$.

Extending the life quality index to include more personal wellbeing through being better off financially (money might not buy happiness but most people would agree that it helps), gives a working definition:

$$Q = G^q X (E_g/E)^p \tag{A7}$$

where $E$ is the average earnings and $E_g$ the salary of a graduate, while $p$ is a parameter to be defined. Note that if $E$ is regarded as a function of $w$ then this will alter the maximum life quality index derivation of $q$ above and make $p$ a function of $q$. This can, however, be ignored as will be shown later. Perturbation by differentiation with respect to an arbitrary variable then gives

$$\Delta Q/Q = q\,\Delta G/G + \Delta X/X + p\,\Delta(E_g/E)/(E_g/E) \tag{A8}$$

and if overall life quality is not to change, while the increase in graduate income is at a cost of the nation's wealth in GDP per capita then for no loss of life quality,

$$\Delta G \leqslant N \times (p/q) \times G\,\Delta(E_g/E)/(E_g/E) , \tag{A9}$$

where $N$ is the number of benefiting graduates. This is the total maximum cost to the state assuming there is no benefit to lifespan $\Delta X$.

From Figure 1, a typical science graduate earnings to average ratio, $E_g/E$, is 1.3 and the rate of change of salary may be assumed exponential over a working lifetime so that

[17] Sensitivity studies were also carried out over $0{:}12 \leqslant q \leqslant 0{:}2$, and the results were found to be insensitive to changes within this range.[9]

$$\partial_t E = b\,E, \tag{A10}$$

where $b$ is a wage growth constant. Defining a similar equation for a graduate wage growth constant $a$, then gives

$$E_g/E = e^{(a-b)t} \tag{A11}$$

and

$$\Delta(E_g/E) = (a-b)\times(E_g/E)\,\Delta T. \tag{A12}$$

Working time in years is $\Delta T$, while typically average salary $E$ will increase by inflation at say 4% per year which sets a value for $b$ as 0.04 while $a$ may be calculated from eqn (A11) using $E_g/E$ and a value of $\Delta T$ of, say, 35 years. The value of $p$ is initially set at unity and the J-value sensitivity is shown in Figure 4. A $p$ value of unity will thus make little difference to the J-value where low ($< 0.20$) $J$ is being considered.

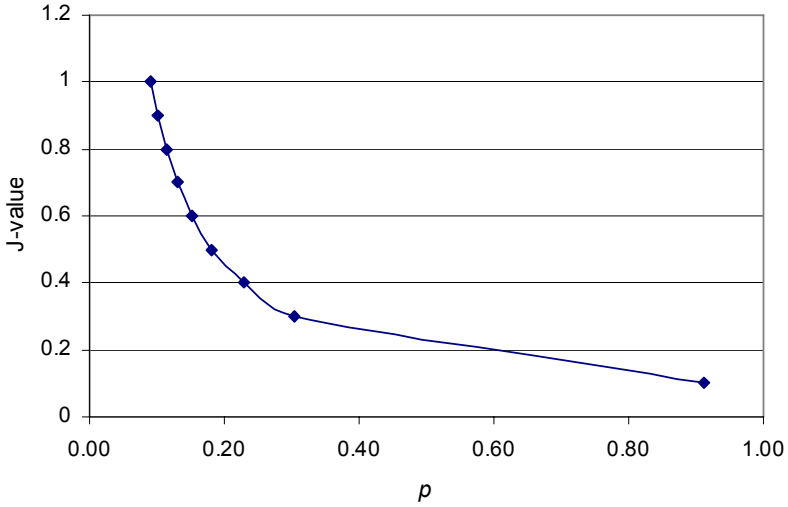


Figure 4. The effect of $p$ on J-value.

The effect of $p$ on the value of $q$ may be evaluated by replacing $\Delta T$ with $w\,X$ and differentiating with respect to $w$ in the extended life quality index (eqn A1), to give

$$q = w/(1-w) + wp(a-b) \tag{A13}$$

for maximum $Q$, and from Table 1 both $w$ and $(a-b)$ are small compared to $q$.