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OECD report demonstrates the benefits of investing in education

The increasing advantages for the better educated, coupled with the likelihood of continuing recession-induced high unemployment, will motivate more and more young people to remain in education, says the OECD. The latest edition of its annual *Education at a Glance* report stresses that governments need to take account of this trend as they review and formulate their education strategies.

'As we emerge from the global economic crisis,' said OECD Secretary-General Angel Gurría, 'demand for university education will be higher than ever. To the extent that institutions are able to respond, investments in human capital will contribute to recovery.'

OECD analyses have shown that a university education pays dividends in later life in the form of higher salaries, better health and less vulnerability to unemployment. In most countries, the difference in income between people with and without degrees continues to grow.

The 2009 edition of *Education at a Glance* calculates the returns on investment in education by balancing the costs of education and of foregone earnings against prospects for increased future earnings as a result of higher educational attainment. According to these calculations:

- A male student who completes a university degree can look forward to a gross earnings premium over his lifetime of more than US$186,000 on average across OECD countries compared to people whose education ends at secondary school.
- For a woman, the figure is lower, reflecting the disparity in many countries between male and female earnings, but the average nevertheless remains high, at US$134,000.
- The highest earnings advantages are in the USA, where a male graduate can expect to earn more than US$367,000 over his lifetime and a female graduate more than US$229,000.
- Italy is in second place for men, with an average lifetime earnings advantage of over $US322,000 and Portugal ranks second for women, with an average advantage of about US$220,000.

In addition, the OECD figures show that there are also advantages for government budgets and the overall economy from higher numbers of graduates. The average net public return across OECD countries from providing a male student with a university education, after factoring in all direct and indirect costs, is about US$52,000 – almost twice the average amount of money originally invested.

For female students, the average net public return is lower because of the lower subsequent earnings, but overall, argues the OECD, the statistics provide a powerful incentive to expand higher education in most countries through both public and private finance.

Among the other findings of the 2009 edition of *Education at a Glance* were:

- The number of people with university degrees or other tertiary qualifications rose on average by 4.5% a year in OECD countries between 1998 and 2006. In Ireland, Poland, Portugal, Spain and Turkey, the increase has been 7% per year or higher.
- In 2007, one in three people in OECD countries aged between 25 and 34 had a tertiary-level qualification. In Canada, Japan and Korea, the ratio was one in two.
- In most countries, the number of people who leave school at the minimum leaving age is falling. However, it is rising in Germany, Japan, Mexico, Poland, Turkey and the USA.
- People who complete a high-school education tend to enjoy better health than those who quit at the minimum leaving age. And people with university degrees are more interested in politics and are more trusting of others.

Source: OECD, Press Release, 8 September 2009.

US risks losing international students to competing countries, warns new paper

Increasing efforts by the UK and Australia, among other countries, could erode the USA's position as the premier destination for international study. This is the warning of a new issue brief from the Center for International Initiatives at the American Council on Education (ACE).

The document is entitled *Sizing Up the Competition: the Future of International Postsecondary Enrollment in the United States*. It examines course registration trends among international post-secondary students in five key destinations for international study – the USA, the UK, Germany, France and Australia. It also looks at national scholarship programmes, visa policies and recruitment initiatives in those countries.

The issue brief identifies several factors that could seriously affect the numbers of international students enrolling in US programmes, including: the global financial crisis, the increasing domestic higher education capacities of countries that currently send their students to the USA, and intensified recruitment by competing countries.

The US Bayh–Dole Act and revisionism redux

Howard Bremer, Joseph Allen and Norman J. Latker

Abstract: *In the past several years various published papers have questioned whether the Bayh–Dole Act of 1980 (The University and Small Business Patent Procedures Act) has in reality been a determining factor in promoting the transfer of technology from US universities, as has been credited to it. This paper responds to that criticism, presenting facts and analysis in support of the contributions universities have made under the auspices of the Act. The authors point out flawed interpretations and misreadings of pertinent data by critics and discuss the circumstances surrounding the inception, passage and implementation of Bayh–Dole.*

Keywords: *Bayh–Dole; Institutional Patent Agreements; university patenting; revisionist premise; US technology transfer*

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Summary

It is no secret that the US economy faces serious challenges. However, the USA has tremendous advantages for succeeding in technology markets to create wealth in the 21st century, if it chooses to exploit them.

That choice lies with policy makers and depends on their recognizing the inherent strengths of the US innovation system. This paper focuses on a key component of that innovation chain: the combination, functioning under the auspices of the Bayh–Dole Act of 1980,[1] of the USA's outstanding research universities and the entrepreneurial spirit that drives the private sector. That partnership has turned the results of publicly-funded science into products, jobs and companies, thus benefiting US taxpayers both economically and through an improved quality of life.

While this linkage between the academic and business sectors is generally believed to have been very successful, a persistent school of critics has charged that such is not the case. These advocates have become more vocal in recent years, urging policy makers to make changes in the Bayh–Dole Act to correct what they view as its shortcomings. Their arguments can be summarized as follows:

- The importance and influence of the Bayh–Dole Act is overrated, or at least unproven.
- Key data that Congress used to pass the Bayh–Dole Act – the small number of 28,000 government-owned patents that were licensed – were misleading.
- Bayh–Dole is not a model that should be adopted by developing countries because of its emphasis on patent ownership. Rather, what should be adopted is the pre-Bayh–Dole model of technology dissemination, stressing open access to scientific discoveries.

It is unfortunate that some policy makers appear to be accepting such arguments at face value. However, it is important to note that these critics lack the perspective of the pre-Bayh–Dole era, and the difficulties then encountered in turning government-funded research into tangible commercial and social benefits for the

> America's trading partners have been quick to follow suit. Odd then, that the Bayh–Dole act [*sic*] should now be under such attack in America.'

Before examining the specific charges that have been used to attack the law, it is helpful to examine why Congress enacted the Bayh–Dole Act, and what it does. Before 1980, inventions that resulted from research supported by federal funding were rarely developed into commercial products. Because most government-funded inventions derive from the conduct of basic research, they are at a very early stage in their development. Consequently, it requires substantial time and investment by the private sector to turn them into commercially useful products and processes. It is frequently estimated that product development requires at least ten development dollars for every dollar spent in conducting the original research. Developing new drugs to market-ready condition can cost between $800 million to $1.3 billion and can take more than a decade. Even with such a resource commitment, commercial success is far from a sure thing. Many more products fail in the marketplace than succeed. Without an ability to protect such investments, commercial development is not possible.

Federal policies before 1980 mandated that any invention made with federal funding – whether made by employees, contractors or grantees – would be assigned to the government. They were then generally made available to all applicants through non-exclusive licences. Thus a company foolish enough to develop a federally-funded invention could not protect its investment in commercialization, since competitors could gain equal access to the technology from the federal government with the additional knowledge that the invention was feasible and there was a market for it.

It became clear that such policies rarely turned the results of government-funded research into commercially-available goods. A series of presidential policy memoranda, dating back to the Kennedy Administration, did allow contractors or grantees to petition funding agencies to acquire ownership of government-funded inventions they had made on a case-by-case basis. Decisions on such petitions by the various agencies could take eighteen months or more, and were generally negative. In the few situations when agencies did grant a petition, they usually also attached many restrictions on the use of the invention.

Not surprisingly, that general policy discouraged innovative small firms from accepting federal research contracts, because the inability to control the resulting inventions undercut their capacity to compete in commercial markets. Additionally, federal agencies and their employees could not receive royalties if their discoveries were commercialized.

President Lincoln, himself a patent owner, envisaged the patent system as 'adding the fuel of interest to the fires of genius'. With regard to federally-funded research, it was evident that those fires were extinguished. This was no small loss because at the time the federal government was funding the majority of basic research – precisely where breakthrough inventions were most likely to occur – and about 50% of all research and development in the country.

The National Institutes of Health (NIH) finally recognized that this general policy was not effective in promoting technology transfer. It was apparent that few, if any, NIH-funded discoveries were ever commercialized. Consequently, in the 1970s NIH adopted an administrative policy allowing universities which had a proven capability to manage inventions to own inventions made with NIH support. Termed the 'Institutional Patent Agreement' (IPA), this was the precursor to a revolution in federal patent policies. That programme proved so successful that it was later adopted by the National Science Foundation (NSF).

However, the IPA programme was undermined during the Carter Administration when the Secretary of Health and Human Welfare (now Health and Human Services) attempted to halt it, and the department later even sought to fire its creator. This reversal prompted several leading universities to approach Senators Birch Bayh (D-IN) and Robert Dole (R-KS) requesting that the IPA programme be made statutory and binding on all federal agencies, and that it be extended to small business contractors.

After examining the dismal record in commercializing federally-funded inventions and the pending loss of competitive markets to Japan and Germany, Congress adopted the NIH/NSF approach in 1980 in what became known as the Bayh–Dole Act.

One important statistic examined by the Senate Judiciary Committee as it considered the bill was that the government was licensing less than 5% of the 28,000 patents on inventions that it had amassed. Universities and small companies presented compelling evidence that potentially important discoveries would never be developed as long as the government took them away from their creators. Thus government policies destroyed the very incentives for development which the patent system was intended to foster. Senators Bayh and Dole stated that such inefficiencies denied US taxpayers the full benefits of their investment in publicly-funded research.

Congress agreed with the Senators' conclusion, and in 1980 it passed the Bayh–Dole Act overwhelmingly. The Act encourages the development of inventions

> 'The political history of Bayh–Dole in Section 4 revealed that it was passed based on little solid evidence that the *status quo ante* resulted in low rates of commercialization of university inventions. More remarkably, the hearings completely ignored the possibility of potential negative effects of increased patenting and licensing on open science and on other channels of technology and knowledge transfer.
>
> Nevertheless, the discussion in Section 5 suggests that the net effects of Bayh–Dole (and the rise of university patenting and licensing activity more generally) on innovation, technology transfer, and economic growth remains unclear, and much more research is necessary on that front. As such, while current efforts to emulate Bayh–Dole type policies in other OECD countries [. . .] are misguided (or at least premature), we also do not have enough evidence to suggest that major changes to the Bayh–Dole act [*sic*] are necessary in the United States.'

Thus, the fundamental premise is that the Bayh–Dole Act was not as influential in promoting the transfer of technology as has been credited to it, and it could be a serious mistake for other countries to emulate it . The first part of the argument is based on assertions by Eisenberg (1996) that experts at the time misunderstood why so few of the 28,000 government-managed patents were being utilized before Bayh–Dole. This failure to commercialize the inventions represented by those patents was a key piece of evidence presented at the hearings on the bill. According to supporters, it showed that the old patent policies (whereby government took inventions away from their creators – the government 'title policy') were ineffective and detrimental to achieving subsequent commercialization. Mowery *et al* (2001, p 117) further postulate that, 'The theory behind Bayh–Dole was that companies needed exclusive patent rights to develop and commercialize the results of university research.'

Actually, the driving force and theory behind Bayh–Dole was that the public was not reaping the full potential benefit from taxpayers' support of basic research, with expenditures for such support amounting to billions of dollars each year. Passage of the Act represented the ultimate step in a long-term effort towards reshaping government patent policy, and was Congress's response to the paramount question: *in whose hands – the federal government or the inventing organization – is the ownership and management of federally-funded inventions best placed to promote the prompt development of important discoveries for the benefit of the US taxpayer?*

It is not denied that, at about the same time as the Bayh–Dole Act was passed, there was a confluence of forces which had an effect on universities' technology transfer efforts. However, we find the proposition outlined by the critics to be a flawed conclusion. The Congressional intention in enacting the law is made abundantly clear in the provisions Senators Bayh and Dole wrote into the legislation as the Policy and Objectives of the Act in 1980 (35 U.S.C. 200):

> 'It is the policy and objective of the Congress to use the patent system to promote the utilization of inventions arising from federally supported research or development; to encourage maximum participation of small business firms in federally supported research and development efforts; to promote collaboration between commercial concerns and nonprofit organizations, including universities; to ensure that inventions made by nonprofit organizations and small business firms are used in a manner to promote free competition and enterprise, to promote the commercialization and public availability of inventions made in the United States by United States industry and labor; to ensure that the Government obtains sufficient rights in federally supported inventions to meet the needs of the Government and protect the public against nonuse or unreasonable use of inventions; and to minimize the costs of administering policies in this area.'

That the effect of the Act was so profound, beneficial and far-reaching is attributable to several primary factors:

(1) It established a uniform patent policy for all agencies of the federal government.
(2) It changed the presumption of title to inventions made in whole or in part with federal monies from the government to universities, other non-profit institutions and small business.
(3) It established a certainty of title in such inventions which encouraged the private sector to engage in relationships with university and non-profit research organizations leading to the development and commercial use of many inventions for the public benefit.
(4) The protection offered by the chosen vehicle for technology transfer – the US patent system – provides needed incentives for the private sector to undertake the considerable risk and expense necessary to take early-stage university discoveries from laboratory to marketplace. Strong patent protection is also vital to small businesses, which have obtained the vast majority of licences from universities, so they can engage the venture capital community for needed funding – and for protection against the incursion of dominant companies in their markets.

Table 1. IPA participants and filing applications, HEW, 1968–1976.

	1968	1969	1970	1971	1972	1973	1974	1975	1976
IPA participants[a]	17	24	34	39	41	50	57	61	66
Patent applications by HEW contractors[b]			35	51	50	44	76	79	118

Sources: [a] Government Patent Policy: Institutional Patent Agreements, Hearings Before the Subcommittee on Monopoly and Anticompetitive Activities of the Select Committee on Small Business, US Senate, 95th Congress, 2nd Session, Part 1, May 22–23, June 20, 21, 26 1978, pp 147–150. [b] Federal Council for Science and Technology Report on Government Policy, Combined Dec. 31, 1973 through Dec. 31, 1976, p 424.

> allowed them to license rights to patented inventions exclusively, firms would lack the incentive to develop and commercialize university inventions.'

And they add a footnote: 'this argument was based on ''evidence'' that government-owned patents had lower utilization rates than those held by contractors, evidence that Eisenberg (1996) has shown to be faulty [. . .]' (the Eisenberg evidence will be addressed later in this paper).

Sampat *et al* (2003) do recognize the existence of the IPA programme and some of the same authors in an earlier paper (Mowery and Sampat, 2001) acknowledge their awareness of that programme more extensively. However, they tend to minimize the connection between the advent of the IPAs and increasing university-sector patenting and licensing when most of the predominant research universities were operating under such agreements.

Interestingly, looking at the actual data, the increase in the filing of patent applications on the results of extramural research sponsored by HEW and NSF directly correlates with the increased participation in their IPA programmes .[5] Table 1 shows the numbers for HEW (then the parent agency of NIH). As can be seen, patent applications increased by over 300% between 1970 and 1976 at HEW as the IPA programme expanded. The numbers are even more striking for the NSF after it implemented the IPA programme in 1973 (see Table 2). NSF had an 800% increase in patent applications between 1973 and 1976 as its IPA programme kicked in.

These data substantiate a strong correlation between the incentives of patent ownership and management under the IPA programme with the subsequent rise in patent applications on university inventions made with federal support. Since the IPA programme was essentially later codified by the Bayh–Dole Act, it is only fair to credit these new approaches to federal patent policies with the increases in university patenting. It is illogical to conclude otherwise.

Yet the critics seem reluctant to acknowledge this connection clearly. Mowery and Sampat (2001) describe the phenomenon as follows:

> '[. . .] Figure 9 [reproduced here as Figure 1] shows that institutions with IPAs dominated the growth of university patenting during the 1970s.
>
> Nonetheless, although IPAs may have encouraged entry by lowering the costs of patenting and licensing, fewer than half of entrant institutions had IPAs. Moreover, Figure 10 [reproduced here as Figure 2] shows that patenting during the 1970s grew for entrants with IPAs and entrants without IPAs. The diffusion of IPAs alone does not explain entry by universities into patenting.
>
> Analysis of the contributions to entry of these various factors – increased inter-institutional dispersion of federal research funding, the growth of IPAs, the rising costs and inefficiencies in Research Corporation's ''central broker'' model, and reduced aversion to university patenting generally and in biomedical technologies in particular – remains an important task for future research. All of these

Table 2. IPA participants and filing applications, NSF, 1970–76.

	1970	1971	1972	1973	1974	1975	1976
IPA participants[a]	na	na	na	na	11	11	13
Patent applications by contractors[b]	6	2	4	8	17	40	67

na=not applicable

Sources: [a] Government Patent Policy: Institutional Patent Agreements, Hearings Before the Subcommittee on Monopoly and Anticompetitive Activities of the Select Committee on Small Business, US Senate, 95th Congress, 2nd Session, Part 1, May 22–23, June 20, 21, 26 1978, pp 258–260; [b] Federal Council for Science and Technology Report on Government Policy, Combined Dec. 31, 1973 through Dec. 31, 1976, p 424.

even more after Bayh–Dole was enacted because it applied uniformly to all federal funding agencies, and all universities in receipt of federal funds for research activities could then engage in technology transfer.

There is therefore little doubt that the negotiation, establishment and existence of the IPAs were of predominant importance in the rapid growth of the university technology transfer function. Moreover, those agreements and the provisions in them were the template for the Bayh–Dole Act. Fundamentally, Bayh–Dole is a codification of terms and provisions of the IPAs. Indeed, when Senators Bayh and Dole first introduced the bill in 1978, they used several inventions whose development was threatened by the Carter Administration's undermining of the IPA programme as examples of the need for legislation.

Additional data support the proposition that the Bayh–Dole Act, drawing on the preceding IPA programme, was a decisive factor in the promotion and growth of the technology transfer profession in the university, non-profit and small business sectors of the economy. Simple statistical evidence, such as the rapid growth in the membership of the Association of University Technology Managers (AUTM) and the number of technology transfer offices established in the university community (from about 30 in 1972 to about 300 in 2007–08) bear that out.

Moreover, data presented in the annual AUTM Licensing Survey that show increasing year-to-year activities in invention disclosures, patenting and licensing are also evidence of the positive effects of the Bayh–Dole Act. The ultimate measure of the wisdom in passing the Bayh–Dole Act and its success in transferring technology for the public benefit – the Act's primary objective – can be found in an annual compilation by AUTM entitled the *Better World Report*, which lists and describes some of the university technology-based inventions which have been developed for the marketplace contributing to public health, safety and welfare – a virtual panoply of inventions in many and diverse scientific disciplines.

Additionally, consider the following evidence of the impact of the law (AUTM, 2007):

- *University technologies helped create 5,724 new companies in the USA since the enactment of the Bayh–Dole Act in 1980.* In FY 2006 alone, 553 new companies were spun off based on campus discoveries and inventions. Astoundingly, that is more than two new companies formed each working day of the year. The formation of new, technology-based companies drives state economic development.
- *University research created 4,350 new products from FY 1998–FY 2006, with 697 introduced in FY 2006 alone.* This means that 1.32 new products were introduced every day for that period.
- *Federally-funded research at universities and federal laboratories resulted in the development for public use of 130 new drugs, vaccines or in vivo* diagnostic devices. Many of these discoveries were treatments for infectious diseases and new cancer therapies. The majority of licences initially went to small companies licensed under the provisions of the Bayh–Dole Act (Jensen *et al*, 2008).
- *There were almost 5,000 existing active university licences in FY 2006 – each representing a university–industry partnership.* The majority of these licences were with small businesses and start-up companies. Although the bulk of licensing arrangements were non-exclusive, most of the exclusive licences issued were to small businesses and start-up companies, which require strong patent protection to succeed in highly competitive markets against larger, established and well-financed competitors.

Important health-related and life-saving discoveries commercialized under Bayh–Dole include: Cisplatin and carboplatin cancer therapeutics (Michigan State University); Hepatitis B vaccine (University of California, University of Washington); Vitamin D metabolites and derivatives (University of Wisconsin-Madison); Human growth hormones (City of Hope Medical Center); Taxol (Florida State University); and Citracal® calcium supplement (University of Texas SW Medical Center).

There was nothing even remotely approximating these successes outside of the IPA program and its subsequent uniform application across all federal agencies caused by the enactment of the Bayh–Dole Act.

The 'evidence' (Sampat *et al*, 2003) disproving the commonly-held theory that government-owned inventions had lower utilization rates than those held by 'contractors' (read 'universities') is based on an article by Rebecca Eisenberg (1996). The same argument is repeated by So *et al* (2008) in their article 'Is Bayh–Dole good for developing countries? Lessons from the US experience'. That paper, intended to warn other countries of the 'dangers' of adopting a Bayh–Dole type law, includes the following passage:

> 'Nevertheless, many advocates of adopting similar initiatives in other countries overstate the impact of BD in the US [. . .] They also cite data (originally used by US proponents of the Act) on the low

1976 report indicating the source of patents granted before 1970, it is not unreasonable to assume that the ratio of these patents is approximately equal to that of the 1970–76 reporting period. That is, about 70% were generated by government employees and about 30% were contractor-generated (including universities and non-profit organizations). Accordingly, of the 7,992 patents granted before 1970, 5,594 would have been generated by government employees, and 2,398 would be contractor-generated. Thus the total DOD employee-generated patents would be 12,640 (7,046 + 5,594) and the total DOD contractor-generated patents would be 4,992 (2,594 + 2,398).

Since DOD employee-generated patents came from cutting-edge federal laboratories like the Naval Medical Center at Bethesda, MD, or the Walter Reed Hospitals in Washington, DC, they do not fit Eisenberg's characterization as 'rejected' inventions without commercial interest. Nor do they fall within her definition of 'contractor' inventions.

The remaining 4,992 patents generated by actual DOD contractors do not support Eisenberg's (1996) allegation that the patents available for licensing 'reflected a huge selection bias; [consisting] largely of inventions made by contractors whose research was sponsored by DOD'. The DOD contractor-generated portion of the government patent portfolio amounts to no more than 18% (4,992/28,021) rather than the 63% (17,632/28,021) suggested by Eisenberg.

There is also no empirical or documentary evidence advanced that even the 18% of the government patent portfolio as identified above were based on inventions 'rejected by contractors' as not 'at all commercially interesting', as Eisenberg argues. This is because an unidentified number of these patents were generated by university and other non-profit contractors and were simply taken by DOD under its existing patent policies, whether they had commercial potential or not.

It is not even possible to support Eisenberg's (1996) contention that there was little commercial value in the unknown subset of patents from for-profit contractors. Most large-company contractors of the time kept their government and commercial research operations segregated because of fears that federal agencies would try to assert ownership to important discoveries. In addition, a proportion of this category of inventions was generated by *small business contractors* who, like universities, had no choice but to assign any inventions made to DOD. Thus Eisenberg's assertion is not proven even for the limited subset of industry contractors.

In summary, the revisionists' theory that the supporters of the Bayh–Dole Act misinterpreted the lack of commercialization of 28,000 government-owned inventions does not hold up. The data present their own case and contradict that theory.

The revisionists are also turning their sights abroad. So *et al* (2008) warn of the dangers of following the US model in a series of recitations of virtually every objection critics have advanced over the past 30 years. Building their case, So *et al* say:

> 'Finally, and most importantly, the narrow focus on licensing of patented inventions ignores the fact that most of the economic contributions of public sector research institutions have historically occurred without patents through dissemination of knowledge, discoveries, and technologies by means of journal publications, presentations at conferences and training of students.'

Such arguments present a false dichotomy. Bayh–Dole has not harmed the dissemination of knowledge in the USA; nor has it prevented journal publications, presentations for the training of students, etc. Indeed, it complements the historical mission of university research by making its contribution to social good much more tangible and immediate through the creation of new products directly benefiting the taxpaying public.

More fundamentally, So *et al* (2008) do not address how developing countries in a competitive global economy can hope to prosper by putting their university research freely into the public domain (as the authors advise). The US experience, as previously discussed, certainly does not support this contention. Unless innovative companies have the incentive of strong intellectual property laws, they cannot undertake the considerable risk and expense of product development. Consequently, public-sector research lies fallow. Rather than following the same course that failed in the USA before Bayh–Dole, developing countries would be well-advised to listen to other arguments.

South American economist Hernando De Soto's groundbreaking book, *The Mystery of Capital* (De Soto, 2000) forcefully demonstrates that the fundamental weakness of perennially underdeveloped countries is the inability of their citizens to establish clear ownership of their property, both physical and intellectual. Without the incentive of ownership, wealth creation is not possible.

At its founding, the United States of America was also a 'developing country'. One of the primary reasons behind the American Revolution was an imperial system that doomed its colonies to remain only the providers of raw materials devoid of manufacturing capabilities. It was to reverse this unjust and subservient role and to develop a society based on internal innovation that the Founding Fathers placed the

consistently higher proportions of articles in the higher percentiles of article citations across the period.

However, when citation rates are normalized by the share of articles during the citation period to produce an index of highly cited articles, the influence of US articles is shown to increase [. . .] In other words, the United States had 83% more articles than expected in the 99th percentile of cited articles in 2005, while the European Union had 16% fewer than expected and the Asia-10 had 59% fewer than expected.'

The USA ranked number 1 in every broad science and engineering field surveyed in the study for 2005. It also held this ranking in 1995.

Another classic argument espoused by the critics is that Bayh–Dole lures academic researchers away from basic research towards applied research in order to attract industry sponsors. Of course, it is precisely because university researchers are doing fundamental research which industry either cannot do or chooses not to do that academic alliances are so attractive. Asking 'Has academic R&D shifted toward more applied work?', the NSF examined this allegation and found as follows (NSB, 2006, Vol 1, p 5–36):

'Emphasis on exploiting the intellectual property that results from the conduct of academic research is growing [. . .] Some observers believe that emphasis has been accompanied by a shift away from basic research and toward the pursuit of more utilitarian, problem-oriented questions.

We lack definitive data to address this issue. As indicated earlier in the chapter, it is often difficult to make clear distinctions among basic research, applied research, and development. Sometimes basic and applied research can be complementary to each other and embodied in the same research. Some academic researchers may obtain ideas for basic research from their applied research activities.

Two indicators, however, bear on this issue. One indicator is the share of all academic R&D expenditures directed to basic research. Appendix table 5–1 does not show any decline in the basic research share since the late 1980s. The second indicator is the response to a question S&E (science and engineering) doctorate holders in academia were asked about their primary or secondary work activities, including four R&D functions: basic research, applied research, design and development.

As figure 5–33 [reproduced here as Figure 4] shows, for those employed in academia who reported research as their primary activity, involvement in basic research declined slightly between 1993 and 2003, from 62% to 61% probably not statistically significant. The available data, although limited, provide little evidence to date of a shift toward more applied work.'

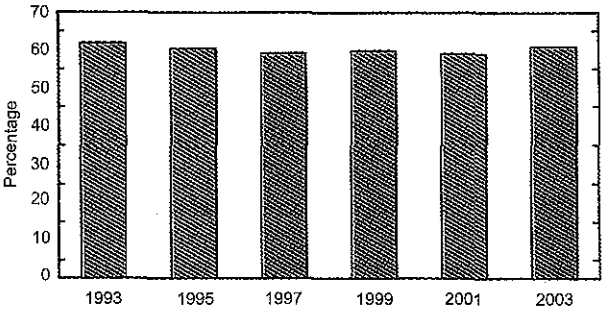

Figure 4. S&E doctorate holders with primary activity research whose primary activity is basic research, 1993–2003.

Note: S&E doctorate holders involved in research include those primary work activity is basic or applied research, development or design.

Source: National Science Foundation, Division of Science Resources Statistics, Survey of Doctorate Recipients, Special Tabulations, from NSB (2006), Science and Engineering Indicators, National Science Board, Arlington, VA.

Once again, an examination of the data contradicts the critics' charges.

To reinforce what the Bayh–Dole Act has contributed to the US economy and to the benefit of mankind, one need only look at the inventions listed below, in addition to those listed previously. Of course, these represent only a small sample of commercialized inventions derived from basic research in academia and generated in diverse disciplines by different university research institutions: rDNA technology, central to the biotechnology industry (Stanford and University of California); TRUSOPT® (dorzolamide) ophthalmic drop for glaucoma (University of Florida); Hotbot Internet search engine (University of California at Berkeley); Ultrasonic removal of dental plaque (University of Washington); Lycos® Internet search engine (Carnegie Mellon University); Mosaic Web browser (University of Illinois at Urbana-Champaign); Yahoo Internet search engine (Stanford); and Cardiovascular and magnetic resonance imaging techniques (University of Wisconsin-Madison).

Conclusion

The Bayh–Dole Act has exceeded the expectations of its authors and of Congress, and is as viable and needed in today's economic crisis as it was in 1980. Its

Prior to the passage of the Bayh–Dole Act, and the preceding Institutional Patent Agreements, the environment in which technology transfer existed was, at best, inhospitable and, at worst, hostile. That environment slowly progressed, through the creation of the IPA program and a succession of unpassed legislation to the enactment of the Bayh–Dole Act, into one that actually encouraged technology transfer. The result has been of great benefit to the US taxpayer in terms of the availability of important new products – particularly in biomedicine – and improved international competitiveness. Indeed, the USA is internationally recognized for its efficiency in the integration of its research universities into its national economy. The proof is in the number of competing nations seeking to adopt the Bayh–Dole model abroad – a movement that persists despite the warnings of its critics.

Unfortunately, the Bayh–Dole Act of 1980 has come under relentless scrutiny and attack by revisionist historians, whose pronouncements have little basis in empirical data. If their criticisms were heeded, the same policies would be resurrected that clearly failed before the enactment of the Institutional Patent Agreements and the Bayh–Dole Act.

It seems strange that a piece of legislation which arose out of failed policies almost 30 years ago and which has proven its worth, is now again being decried on many of the same bases that were raised against its initial passage. Outspoken claims, with little basis in empirical evidence, under the guise of guardianship of the public interest provide a rich field for the cultivation of political power and special interests. Such initiatives are dangerous in an evolving technologically-focused, increasingly fragile, global economy. Intellectual property and its ownership have become the preferred currency for economic growth, with invention and innovation the hallmarks not only of technological leadership, but of survival.

The authors of this article fully acknowledge that improvement can always be made in the technology transfer system. It is always possible to find licensing decisions that could be open to criticism or universities that are more difficult to deal with than others. However, it is important not to blame Bayh–Dole for sub-optimal practices on the basis of examples of its poor implementation.

The bottom line is that the Bayh–Dole Act, over its 30 years of implementation, continues to provide a superb framework for government-funded research to benefit Americans through job and wealth creation, and to improve the lives of people worldwide. This is a lesson it would be well to remember, and perhaps one that the critics could take to heart. As Nietzsche said, 'Convictions are more dangerous foes of the truth than lies.'

Notes

[1]University and Small Business Patent Procedure Act, P.L. 96–517, 1980 (commonly referred to as the 'Bayh–Dole Act' or, simply, 'Bayh–Dole').
[2]Small Business Innovation Development Act of 1982, P.L. 97–219, July 22, 1982, 96 Stat. 217.
[3]Testimony of Elmer B. Staats, Comptroller General of the United States, before the Senate Judiciary Committee on S. 414, the University and Small Business Patent Procedures Act, May 16, 1979, Report No 96–11, p 37.
[4]The GAO patent policy study presented to the Senate Judiciary Committee on 16 May 1979 also found that the Department of Energy frequently took up to 15 months to process these patent ownership requests from its contractors.
[5]Government Patent Policy: Institutional Patent Agreements, Hearings before the Subcommittee on Monopoly and Anticompetitive Activities of the Select Committee on Small Business, US Senate, 95th Congress, 2nd Session, Part I, May 22–23, June 20, 21, 26 1978, pp 147–150; and Federal Council for Science and Technology Report on Government Patent Policy, Combined Dec. 31, 1973 through Dec. 31, 1976, p 424.
[6]See: http://web.mit.edu/newsoffice/2009/kauffman-study-0217.html?tr=y&auid=4551551.
[7]Federal Council for Science and Technology Report on Government Patent Policy, Combined Dec. 31, 1973 through Dec. 31, 1976.
[8]*AUTM Licensing Survey, FY 1999* (Pressman, 2000) – see pp 1,3,7,8 and 22. Economic numbers derived from approaches by Stevens, 1994, and Pressman, 1995.

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Leadership in university-based cooperative research centres

A qualitative investigation of performance dimensions

S. Bartholomew Craig, Clara E. Hess, Jennifer Lindberg McGinnis and Denis O. Gray

Abstract: *In spite of the importance often attached to the role played by leadership in university-based cooperative research centres, we know very little about what 'leadership' means in this specific context. The research reported here used a qualitative approach to identify fifteen dimensions of leadership performance for directors of university-based cooperative research centres, which might serve as the basis of a future quantitative leadership performance measure. Nineteen university faculty members working in research centres were interviewed, and their responses were content-analysed to identify both facilitators and inhibitors of centre directors' performance. Facilitative performance dimensions included: technical expertise, ambition/work ethic, broad thinking, embracing ambiguity, balancing competing stakeholders, leveraging social capital, obtaining resources, navigating bureaucracy, granting autonomy, interpersonal skill, team building and task adaptability. Inhibiting performance dimensions included: abrasiveness, disorganization and conflict avoidance. The results are discussed in terms of the commonalities and particularities they reveal about cooperative centre leadership relative to leadership performance in other settings.*

Keywords: *leadership; cooperative research centres; industry–university partnerships*

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As the global drive for new technologies increases, organizations of all types explore new methods of generating new knowledge and inventions. University-based cooperative research centres (UCRCs) are one form of organization designed to bring together academics, scientists and people from industry to conduct research and development (R&D). UCRCs are specialized research organizations in which academic researchers collaborate with industrial partners to focus R&D efforts on promoting scientific discovery and

Table 1. Summary of selected R&D leadership research.

Topical focus	Study	Key proposition(s)
Importance of leadership in R&D settings	Andrews and Farris, 1967	Supervisory practices predict R&D team performance.
	Judge *et al*, 1997	Identified four R&D management practices that contributed to a culture of innovation and goal-directedness.
	West *et al*, 2003	Existence of formal leadership roles facilitates innovation.
	Cardinal, 2001	Attention, motivation, and encouragement by R&D leaders predicted innovation in the pharmaceutical industry.
	Cordero and Farris, 2004	R&D leaders' administrative, people and technical skills contributed to a more 'stimulating' work environment, which in turn predicted team members' satisfaction and performance.
Uniqueness of leadership in R&D settings	Simonton, 1984; Dudeck and Hall, 1991	Unstructured nature of R&D work requires more structure, expertise and direction from leaders.
	Basadur *et al*, 2000	R&D leaders must possess the skills necessary to evaluate creative ideas and projects.
	Howell and Higgins, 1990; Shim & Lee, 2001	R&D leaders must span boundaries to wield influence over multiple constituencies.
	Schon, 1963; Howell & Higgins, 1990; Shim & Lee, 2001	R&D leaders must act as 'champions' to promote ideas or projects through informal networks.
	Mumford *et al*, 2002	Innovation workers tend to be more intrinsically motivated than extrinsically, limiting R&D leaders' choice of motivation tactics and requiring greater persuasive skill. Tension between innovative efforts and organizational constraints requires R&D leaders to span boundaries and navigate multiple constituencies and relationships.

the R&D leadership literature can be found in Elkins and Keller (2003).

Given the importance of R&D to firm performance, including the 'bottom line', it is not surprising that there is a growing literature on leadership in this setting. This literature has highlighted critical leader roles, the potential impact of leaders on organizational outcomes such as climate and theories that seem particularly relevant for this setting (Elkins and Keller, 2003). However, the relevance of this body of scholarship for leaders involved in UCRCs is less clear.

University-based cooperative research centres

Just as leaders of research and development functions experience different requirements and structural characteristics from those faced by leaders outside the R&D function, UCRC leaders experience different requirements relative to R&D leaders in more traditional settings. Some of these distinctions regarding leadership develop from the differences between regular R&D divisions embedded in larger organizations and UCRCs that function as partnerships among industry, academic institutions and governmental organizations.

These academically-based centres are designed to foster technology transfer between universities and firms. Universities often participate in UCRCs because of the funding available through them, while firms find the relationships with academics useful, especially when the partnership allows them to downsize their in-house R&D divisions (Adams *et al*, 2001). Geisler and Rubenstein (1989) noted additional reasons why firms and universities participate in UCRCs, such as exposing students to practical problems, potential employment for graduates and access to technology areas in which industry has expertise. Industry partners participate to gain access to students and professors as well as to technology for problem solving. Other benefits include gaining prestige through association with an academic institution and obtaining state-of-the-art information.

There are several strengths to the UCRC as an organizational structure. First, Blumenthal *et al* (1986) found that industry-financed university R&D in biotechnology yielded a higher proportion of successful patents than internal R&D. Similarly, Adams *et al* (2001) found that UCRC laboratories were more science-based and 2.5 times larger than comparable

Each participating director was asked to provide contact information for four individuals in the centre who could comment on their leadership, and those individuals were then invited to participate by the authors. Eleven staff and faculty members agreed to participate and served as observers of six of the directors' leadership behaviour. Of these observers, one was a centre co-director; six occupied subordinate leadership roles in their centres (referred to here as 'assistant directors'); two were representatives of industry partners; one was a principal investigator (PI); and one described himself as both a PI and an assistant director. Although this sample size of 19 is not large by the standards of quantitative research, it was deemed adequate for this initial qualitative inquiry into a previously unexplored area.

Procedure

Data collection. All participants were interviewed by telephone or in person using standardized protocols developed for this study. The interview protocol for directors contained 20 questions and took about 90 minutes to complete (see Appendix A). The protocol for observers contained 13 questions and took about 50 minutes to complete (see Appendix B). Interview questions were developed by the authors on the basis of previous theory and research on leadership. Participants were assured that responses would not be attributed and were encouraged to be candid. Interviews were audio-recorded and subsequently transcribed to electronic text files.

Content analysis. Transcribed interviews were imported into *NVivo 7* software for analysis (QSR International, 2006). Prior to content analysis by the first three authors, a calibration session was held to familiarize the three coders with the grounded theory approach to content analysis, in which response categories were allowed to emerge from the data rather than being specified *a priori* (Glaser and Strauss, 1967). All three coders subsequently coded the same three interviews, compared their results and discussed discrepancies to the point of resolution. The remaining 16 interviews were divided among the three coders. For the purpose of the current study, responses were coded into categories that reflected types or dimensions of centre director performance. A given response was allowed to be coded into more than one category. Category frequencies were calculated to indicate how often each performance dimension was mentioned. Because there were only eight centre directors, they were combined with observers into a single respondent group for analysis. Although it would have been desirable to provide separate results for directors and observers, it was decided that the sample size of eight directors, if analysed separately, would have yielded frequency counts that were too sensitive to infrequent responses (for example, just two responses in a category would indicate a 25% endorsement rate).

Table 2. Dimensions of UCRC leader performance.

Bright side	Dark side
Technical expertise	Abrasiveness
Ambition/work ethic	Disorganization
Broad thinking	Conflict avoidance
Embracing ambiguity	
Balancing competing stakeholders	
Leveraging social capital	
Obtaining resources	
Navigating bureaucracy	
Granting autonomy	
Interpersonal skill	
Team building and maintenance	
Task adaptability	

Results and discussion

Fifteen dimensions of UCRC leader performance were identified, including 12 positive or desirable dimensions and three negative or undesirable dimensions (see Table 2). This distinction is consistent with recent research that has emphasized the importance of both 'bright' and 'dark' sides to leadership (Hogan and Hogan, 2001).

The importance of *obtaining resources* was mentioned by the most respondents (91%). This category included any reference to the need for directors to procure monetary or non-monetary resources for their centres, from either public or private sources. A sample response from this category was:

> 'My job is to make sure that we have a revenue stream that is substantial enough to support the research that our membership desires.'

Technical expertise was mentioned by 75% of the interviewees. Responses were coded into this category if they included a reference to the director's specialized skill, training or experience in the technical domain of the centre's research. A sample response from this category was:

> 'You've got to understand the technology, for one thing. Even though some of the technology is pretty far away from your original training. You have to teach yourself some of these things because you've got to know what's going on in the centre.'

The *ambition or work ethic* of the director was mentioned by 63% of respondents. Responses were

> 'I was basically able to tap into many of the people that I had already known, some of them for 10 years, and to interest them in the kind of work that we were doing for these companies. So I think that was probably the biggest thing that I had going for me – I had a good network in place when I started the centre.'

The category we called *task adaptability* referred to demands on the director to alternate between leadership tasks and individual contributor tasks – to function both as a leader of researchers and as a researcher. Nine per cent of respondents mentioned this as being a success factor for directors. One director said:

> '[A strength is] being able to do my science. You know, when I came into this six years ago, I didn't want to go into an administration-like role. I wanted to continue to be a strong contributor on the science and engineering side of the equation. And so the things that I look at in regards to my own success or where I want to be is my own research productivity – my students, my papers, my extramural research funding. My group's as strong as it's ever been, and I'm really excited about it.'

The final three categories were labelled 'dark side' categories because their presence was reported to inhibit directors' effectiveness. Most of the responses to the interview questions about inhibiting factors were couched in terms of directors *not* carrying out effectively tasks already described above in the 'bright side' categories, but the following three categories emerged as distinct from simply 'not doing' something positive.

Abrasiveness refers to directors' tendency to damage relationships or act in such a way as to induce other people to attempt to thwart their objectives. They may do this by displaying arrogance or impatience or by being pushy. Thirty-eight per cent of respondents mentioned a director's abrasive behaviour as something that inhibited their effectiveness. One director remarked:

> 'It has [inhibited my effectiveness] because all it takes is locking horns one time with a stubborn uninformed dean and you're in deep trouble. And you know it doesn't matter then; you can be worth, you know, 20 million dollars to the university and if you just tell the dean off because of your impatience with their stupidity or with their failure to understand what you're doing then you're toast because they will block you at every turn and they have that power and they exercise it and it's naive to think they don't, because they do. You know it happens.'

Thirty-eight per cent of respondents mentioned a director's *disorganization* as being an inhibiting factor. These comments included references to directors failing to attend to details or forgetting to follow through on commitments. One centre faculty member commented:

> '[My director] perhaps had a breadth of vision but couldn't necessarily drive everything to a conclusion.'

Conflict avoidance was mentioned by 18% of respondents as preventing directors from being as effective as they might otherwise be. These comments included references to a lack of assertiveness or to procrastination to avoid uncomfortable conversations. A sample comment was:

> 'I think that sometimes he avoids conflict because that is not his demeanour or character. And sometimes you just have to have some conflict to work different issues out and he would much rather sweep it under the rug, so to speak, and let it die and somehow, some way, surely it's going to pass over and everything will smooth itself out. And sometimes I think you just have to stand up to someone and say, ''You know, what? You're wrong. This is why you're wrong. And I still like you as a person. I still like you as a researcher or whatever the situation may be, but I'm the boss and this is the way we're going to do it.'' And he will do that, but it is very hard for him to do that and it takes a lot of coaching to get him to do that and say you really need to handle this. This isn't something that I can handle for you. So I would say that is definitely his weakest point.'

Uniquenesses of the director's role

Several previous research efforts have investigated the demands of leadership roles in settings other than R&D. Using exploratory factor analysis of performance rating items, Tornow and Pinto (1976) and Morgan (1989) separately arrived at lists containing 13 dimensions of leadership behaviour, though their lists were not identical. Mintzberg (1989) proposed 10 'managerial roles' in his now classic text. Later, Fleishman *et al* (1991) proposed a general integration of those and other taxonomies, again arriving at a list containing 13 dimensions of managerial behaviour (though, again, not sharing identical labels with previous 13-factor taxonomies).

A comparison of the dimensions identified in the present study with those previously identified in

of UCRC leadership. By identifying dimensions of UCRC director performance, including areas of commonality and uniqueness relative to leadership in other settings, we hope this study will provide a foundation for future research to continue to advance our understanding of leadership in this important organizational type.

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Appendix B

Observer interview protocol

Background

1. What is your job or role in the centre?
2. What factors are most important to your success in your role?
3. What motivates you in your work with the centre? [Wait for answer.] What role does the director play in your motivation?

About the director

4. What are the director's primary strengths?
5. What are the director's primary weaknesses or limitations?
6. How effective is the director at maintaining productive relationships with other people, both inside and outside the centre? [Wait for answer.] What would make him or her more effective?
7. How effective is the director at achieving the centre's mission (that is, in delivering results)?
8. How effective is the director at the administrative aspect of his/her role?
9. How effective is the director at creating a compelling vision for the centre?
10. How effective is the director at communicating with centre constituents?
11. On a scale from 1 to 10, where 5 is adequate and 10 is outstanding, how would you rate your centre director's performance? [Wait for answer.] What would he/she need to do to get a higher rating?
12. If you could change only one thing about your director's leadership, what would it be?
13. Are there any other comments you would like to make about the director's leadership?

The role of higher education and industry in supporting career goals and decision making

Yolanda Jordaan

Abstract: *Both higher education institutions and employers need to evaluate the factors that influence students' career goals and career-related decisions because of their importance to and impact on career management and decision making. The objective of this study is to identify the importance of career goals and factors influencing students' career decision making in South Africa. A non-probability sample was selected, with 488 completed responses. The findings indicate that there are significant differences between gender and ethnic groups in terms of the importance of career goals and career influencing factors. The results suggest that high-quality education is needed in conjunction with industry involvement through proper job training and/or internships.*

Keywords: *student careers; career decisions; career management; skills training; South Africa*

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The post-*apartheid* period (after 1994) has seen the beginning of an initiative to get previously disadvantaged South Africans into good jobs so that they can learn new skills and develop their careers. One way they can do this is through Black Economic Empowerment (BEE), which aims to redistribute wealth and provide equal opportunities to previously disadvantaged individuals (*Enterprise*, 2005). However, BEE policies and their application at all costs can damage the South African economy and have been criticized for several reasons. First, some believe BEE is exclusive, because the resulting policies seem to benefit primarily big businesses at the expense of small and medium-sized businesses (*Enterprise*, 2005). Second, if skilled people are compelled to leave their jobs simply because their skin colour is inappropriate and there are no suitably skilled replacements, everyone suffers (*Citizen*, 2005). The solution for BEE seems to lie in job creation and skills training, as the gap between rich and poor will continue to increase for as long as the skills gap remains (Lubbe, 2008).

Many South African companies complain that they are unable to meet affirmative action quotas because of the shortage of qualified black people (Momberg, 2008). This view is supported by findings from a study published by Deloitte and Touche, which indicates that 81% of companies experience difficulty in recruiting staff because of the skills shortage (Momberg, 2008). More specifically, South Africa is experiencing a shortage of critical skills (in the areas of finance,

awareness of their aspirations; those who are uncertain about their specific goals but have identified general ideas and possibilities; and those who currently have no ideas or aspirations for the future. For the purposes of this study, the assumption is that students have a clear awareness of their objectives in terms of their career goals.

Many international studies have investigated career goals and their role in career planning. In a UK study, Counsell (1996) identified ten career goals with which students associated: wealth; overall job satisfaction; a managerial position; working abroad; working with people; managing their own business; variety in work done; being well-qualified; being good at the job; and challenging work. Counsell's (1996) findings identify 'wealth' as the most frequently mentioned career goal by the students surveyed. However, only 24% of the female respondents mentioned 'wealth', compared to 55% of the males. The career goal most frequently mentioned by females (28%) was 'overall job satisfaction', whereas only 31% of male respondents mentioned this as a career goal. Twenty-two per cent of female respondents identified 'working abroad', compared with six per cent of males, while 16% of male respondents mentioned 'being good at the job', as opposed to only one per cent of the female respondents. The remaining six career goals did not show significant differences between the two gender groups.

In a US study by Piotrowski and Cox (2004), the major motivation for undergraduate business students in terms of career goals was to enhance employment opportunities and income. Piotrowski and Cox suggested that future researchers should examine gender differences with student samples while focusing on the classification of students (that is, first year versus senior students).

From the findings of previous studies, it seems that the setting of career goals is correlated with students' perceptions of their career opportunities. This is probably because it enables them to gain a better understanding of a particular field of study and their specific career path. Furthermore, goal setting is an important aspect of career planning and should ideally begin at an early point in a degree programme in order to discourage the tendency to postpone important decision making processes (Ribchester and Mitchell, 2004).

Career decisions

Some people believe that school graduates do not have the support systems and information required to make informed career decisions. There is evidence that many school graduates decide on a potential career for the wrong reasons – for example, because the career sounds glamorous, because their friends are going into it, or because they feel forced to live out their parents' dreams (Pauw, 2009). Students are under pressure to make the right decisions when presented with a wide variety of options in higher education institutions. It is therefore important to understand which factors could influence the career choices that will impact on a student's career-related thinking. An early study by Anderson *et al* (1992) indicated that experience, the media and role models mainly influenced US students' career decisions. A study by Counsell (1996) established ten sources of career-related decision influences: information and advice from parents and close relatives; friends and acquaintances; work experiences; courses and subjects studied; tutors; role models; family ties and commitments; economic situation and job market; perceived needs; and perceived skills and abilities. Several other authors agree that relatives, friends and tutors can influence career-related decisions (Clark, in Counsell, 1996; Counsell and Popova, 2000; Sosik *et al*, 2004). Counsell and Popova (2000) identify two additional influences – limited education/learning opportunities and ethnic considerations.

Focusing on Counsell's (1996) ten most influential factors for career-related decisions, 'information and advice from parents and close family' seemed to be the strongest factor. Closer investigation of gender differences indicated that male and female respondents did not differ in the identification of 'information and advice from parents and close family' as the most frequently mentioned career goal. Male and female respondents did, however, differ significantly in the identification of 'tutors', 'role models' and 'perceived skills and abilities' as influences on career-related decisions. For example, 16% of females considered 'tutors' as important, compared to four per cent of males. No significant gender differences were found among the remaining six career-related decision influences.

One of the factors mentioned by Counsell (1996) is the influence of role models in career-related decisions. A role model is someone whose behaviour in a particular role is imitated by others. Prior research by Anderson (in Perrone *et al*, 2002) shows a strong association between career decidedness and the influence of role models. Role models influence career choice not only by direct modelling and imitation, but also by offering support when the individual identifies strongly with the role model. Betz (in Perrone *et al*, 2002) noted the importance of role models and mentors in facilitating positive career development, particularly for females, while Counsell (1996) found that males are more likely than females to be influenced by role

Committee, lecturers and respondents, and no incentives were provided for questionnaire completion. A total of 593 questionnaires was distributed, of which 488 were completed and returned, representing a response rate of 82%.

Measurement instrument

The initial questionnaire was pre-tested among 20 undergraduate BCom students. Cooper and Schindler's (2006) collaborative participant pre-testing was used and students indicated an important career goal that had not been included in the original list of goals; this was 'opportunities for promotion'. This career goal was then included as another item in the questionnaire. The questionnaire had three sections. The first of these consisted of an 11-item, five-point Likert-type scale used to measure the level of importance students placed on career goals, ranging from 'very unimportant' (1) to 'very important' (5). The first ten of the scale items were taken from the research by Counsell (1996), and 'opportunities for promotion' was added to these.

The second section of the questionnaire consisted of a 13-item, five-point Likert-type scale which measured the importance students placed on the factors influencing career-related decisions, ranging from 'very unimportant' (1) to 'very important' (5). The career-related decision factor items consisted of the 12 items identified by Counsell's (1996) research and the additional influence identified by Anderson *et al* (1992) – 'information obtained from media'.

The final section contained socio-demographic questions on matters such as gender, home language, ethnic orientation and year of study.

Data analysis

Data analysis consisted of descriptive statistics (mainly the ranking order of career goals and career influences) and hypothesis testing. Multiple analysis of variance (MANOVA) was used to test the hypotheses, as it uses univariate tests to assess the differences between groups collectively rather than individually. The objective of MANOVA is to test for differences in the mean values of several dependent variables (Lattin *et al,* 2003). The Wilks' lambda test statistic was used to assess the overall significance of the MANOVA because it is relatively immune to violations of the assumptions underlying MANOVA without compromising on power (Hair *et al*, 2006).

Results and discussion

The total realized sample was 488 respondents and the profile included 64% females and 36% males. The ethnic orientations were represented by 75% white and 25% black students. The population statistics for undergraduate BCom students at the University of Pretoria are 54% females and 46% males, with 66% white and 34% black students (Department of Education, 2008). It should be noted, however, that it was not intended that the sample profile should mimic the population profile, since a non-probability sample was drawn. At this point it may be relevant to note that the racial categorization system of black and white used in this study is considered to be a valid basis of differentiation, as these are the classification terms used by Statistics South Africa (StatsSA) to classify race in the country's population censuses. Additional sample statistics include the range of home languages, namely 34% English-speaking, 37% Afrikaans-speaking, 23% African language speakers, with six per cent grouped under 'other language' (such as German, French or Portuguese). With regard to the year-level range: 43% of the students were at first-year level, 15% were at second-year level and 41% were at third-year level.

Importance of career goals

Career goals are considered to be an important starting point in career management. It is advisable for students to set goals to further their careers since it can be assumed that setting career goals plays a positive and pivotal role in guiding students' actions in the fulfilment of future career needs. Table 1 provides the ranking of the different career goals in order of importance, based on the mean values of each career goal. As can be seen, the top four career goals are 'being good at the job', 'overall job satisfaction', 'opportunities for promotion' and 'being well-qualified'. One may feel that these four career goals 'tell a story', in that the respondents indicate that they want high-quality education so that they can be good at their jobs to optimize opportunities for promotion and attain overall job satisfaction. Since 'being good at the job' was the most important goal, it can be surmised that there is a value system in place, according to which students want to excel at their jobs and contribute to the economy – at least so far as the Commerce students in this study are concerned. It is worth noting that wealth as a career goal was the seventh most important factor, whereas, as described above, it was considered the most important career goal among UK students (Counsell, 1996). It may be that wealth is not as important to South African students since the cost of living is lower than it is in the UK. The least important goal was to work abroad in the future, whereas it was the fourth most important career goal of the UK students in Counsell's (1996). This finding is somewhat surprising, and is contrary to many media reports claiming that South Africa is experiencing a brain drain, with many young graduates leaving the

Table 3: Mean values and MANOVA results for gender groups' career goal perceptions.

Career goals	Male	Female	Univariate analysis
Wealth	4.20	4.03	**0.028**
Overall job satisfaction	4.59	4.75	**0.006**
A managerial position	3.97	3.98	0.886
Working abroad	3.51	3.46	0.634
Working with people	3.83	4.01	**0.048**
Managing your own business	3.84	3.74	0.335
Variety in work done	4.07	4.24	**0.027**
Being well-qualified	4.36	4.62	**0.000**
Being good at the job	4.71	4.80	0.058
Challenging work	4.10	4.25	0.051
Opportunities for promotion	4.51	4.60	0.187
Wilks' lambda:			
F-value 3.289			
p-value **0.000**			

Table 4. Mean values and MANOVA results for gender groups' perceptions of career influences.

Career influences	Male	Female	Univariate analysis
Information and advice from parents and close family	3.92	3.97	0.503
Friends and acquaintances	3.51	3.45	0.423
Work experiences	3.95	4.09	0.102
Courses and subjects studied	3.97	4.17	**0.007**
Tutors	2.91	3.12	**0.037**
Role models	3.57	3.40	0.082
Family ties and commitments	3.64	3.55	0.307
Job availability	4.11	4.30	**0.029**
Personal future needs	4.49	4.65	**0.003**
Perceived skills and abilities	4.17	4.36	**0.005**
Limited education and/or learning opportunity	3.27	3.56	**0.002**
Considerations regarding affirmative action and employment equity opportunities	3.06	3.46	**0.000**
Information obtained from the media	3.18	3.39	**0.028**
Wilks' lambda:			
F-value 3.512			
p-value **0.000**			

their parents had to make their career choices. Table 2 also shows that 'personal future needs' is the most important influence for the sample. Students may feel their personal future needs are important, especially in post- *apartheid* South Africa. The career influence that achieved the lowest rating was 'tutors', which may reflect the lack of career counsellors and tutors available in the education system (Kellaway, 2009).

Hypothesis testing

Hypothesis 1

The first hypothesis was related to the possible differences between male and female students with regard to the importance they attached to career goals. Table 3 depicts the MANOVA results for the different gender groups regarding their perceptions of the importance of career goals. The Wilks' lambda value in Table 3 indicates a significant difference (p=0.000) between male and female students in terms of the levels of importance they attach to career goals. The null hypothesis can therefore be rejected, as there is support for H_1. The univariate tests indicated significant differences between gender groups for five of the eleven career goals. The p-values indicate differences in terms of 'wealth', 'overall job satisfaction', 'working with people', 'variety in work done', and 'being well-qualified'. In all significant career goals, females exhibited stronger importance levels, except in the case of wealth as a career goal. This concurs with Counsell's (1996) findings, which indicated that males attached higher importance to wealth than females. The high importance of wealth as a career goal for males may well be linked to the notion that males are the financial providers for the family, with females believing that they have other roles to fulfil (such as being a mother). The higher response rates exhibited by females overall may, however, be a result of different response styles exhibited by gender groups.

Hypothesis 2

In Hypothesis 2 the differences between male and female students with regard to the importance of influences on their career decision making were considered and the results are depicted in Table 4. The MANOVA test result (Table 4) indicates a significant difference (p=0.000) between gender groups in terms of the importance levels of career influences on decision making. The null hypothesis can therefore be rejected, as there is support for H_2. It is clear from Table 4 that seven factors reflected significant differences between males and females with regard to the importance of specific factors for their career-related decisions. In all cases, female students attached more importance than males to these career influences (as is evident from the higher mean values). As mentioned earlier, this may be the result of typical female response styles (generally being more positive when rating items). These significant different career influences include: 'courses and subjects studied', 'tutors', 'job availability', 'personal future needs', 'perceived skills and abilities', 'limited education and/or learning opportunities', 'considerations regarding affirmative action and employment equity

'being good at the job', 'deriving job satisfaction', 'availability of promotion opportunities' and 'being well-qualified for the job'. Regarding influences on decision making, the following career influences ranked as very important: 'personal future needs', 'skills and abilities needed for the career', 'job availability' and even the role of 'courses and subjects studied' in preparation for the degree. These findings suggest that stronger links may be necessary between higher education and industry. Higher education has to a great extent provided generic skills, such as research, numeracy and problem solving, but there is also a need for the provision of managerial, leadership and team-working skills development to prepare students for the world of work. To address the skills issue, the South African Ministry of Education released the National Plan for Higher Education in 2001 to increase participation rates for young people and to shift the balance between humanities, business and commerce, and science, engineering and technology. The Ministry also mandated several institutional mergers in an attempt to create comprehensive universities – institutions offering both university and technikon-type programmes under the same umbrella (Department of Education, 2004). This study therefore has implications for certain interest groups that are, or should be, involved in the career decision making processes of higher education students.

One of the main implications relates to the role of education providers to inform and educate students about career goals and career decisions. This should include factors such as ensuring that students are well-qualified for the job by providing relevant courses and subjects. Several institutions have founded bridging or extended programmes in various faculties, such as Natural and Agricultural Science, Education and Engineering, to address national skills shortages and to ensure well-qualified individuals (MacGregor, 2009). However, empowering individuals with information begins at school level with the important role of school counsellors in the career management process. Proper career counselling should include testing learners to get an idea of aptitude, intelligence and interests. Unfortunately, many believe that career counselling services in South African schools are insufficient or even non-existent (Pauw, 2009; Kellaway, 2009). As universities are facing a growing problem in placing graduates in an employment market which is extremely competitive, they may want to consider investing in career development programmes for students as a supplement to student guidance services. Many institutions offer free psychometric testing to enrolled students to assist them in making career decisions (Pauw, 2009). The question is, however, whether these services are not offered too late in the career management process, and also whether they are properly marketed to students, as many seem unaware that such services are available. In South Africa, with many previously disadvantaged students now in the higher education system, universities may also want to consider offering more support services in the form of tutorials and/or bridging courses to students who are struggling with course work.

There is evidence that career guidance enhances a person's career development and enables him or her to make more effective career-related decisions (Esters, 2007). Green and Saridakis (2008) posit that students' higher education experiences influence individual outcomes and that higher education plays a beneficial role in supporting graduate employment. In general, the number of graduates in the labour market has increased, resulting in an oversupply of applicants for certain graduate placements. This imbalance between supply and demand may signal to higher education institutions that they need to invest resources in programmes that optimize students' job seeking success, while also providing career management skills to graduates. One such career development strategy was implemented at the Victoria University in Melbourne; the results showed that students found it extremely valuable for their job-search skills, their self-awareness and their strategies to achieve their employment goals (Miller and Liciardi, 2003). If higher education institutions encourage students to set career goals, students will be able to take responsibility for their careers, and they thus become more skilled and therefore more useful to industry (Greenhaus *et al,* 1995). Higher education institutions and students will both benefit from well-designed and maintained career management systems. Derek Wilcocks, Services Director for the Middle East and Africa at Dimension Data, believes that talented individuals are still opting for career paths indicative of poor career decision making as a result of the way they are counselled, or not counselled (Webster, 2008). This is where career management programmes can help individuals to obtain a realistic view of their career goals and decisions.

Another implication of the study relates to the involvement of industry in the career decision making processes of students (or future employees). People change and develop over time, and therefore industry would benefit from knowing which goals students set so that they can attract graduates more effectively and retain employees. Students who set career goals are more likely to have productive and satisfying careers (Greenhaus *et al,* 1995). It was found in this study that students identified 'being good at the job' as the most important career goal. Employers, therefore, need to

promotion. Career management systems can be improved if managers take into account the factors that influence students' career goals and career-related decisions. Employers could, for example, make better use of the media to attract black students, because this ethnic group regards 'information obtained from the media' as a more important influencing factor in career choice than do white students. Both higher education institutions and industry can help students to take greater responsibility for their career goals and planning, as today's students have to educate and market themselves continually to thrive in the fiercely competitive job environment (Kuijpers *et al*, 2006). Higher education institutions could consider graduate career portals for their alumni to help industry to locate experienced talent (Mnqeta, 2008). Such portals could be used to market alumni directly to industry partners, thereby creating a meeting place where talent-seekers and job-hunters could meet.

Limitations and directions for future research

A limitation of this study is that it was conducted at only one tertiary education institution in one faculty, and the results cannot be generalized to the broader population. Also, the non-probability convenience sample lacks control to ensure precision of the sampling method, making it non-representative of the population. Future research should make use of a larger sample of students from more faculties at more higher education institutions, including both part-time and full-time students (employed and unemployed), validating the results by exploring other geographical areas.

The current study represents a snapshot of the current career perceptions and career goals of undergraduate students in South African higher education institutions. A longitudinal study, with tracking of students as employees, could help to establish the validity and consistence of their career goal setting. It is important to note that the assumption was made that students had already identified clear career goals. Furthermore, it may be necessary to extend our understanding of the career progression of graduates. Future studies might investigate the current state of career counselling services available at both school and university levels, as well as the effectiveness of the different services available. Another possible area of investigation is the information sources learners and/or students consult when gathering information on future careers. It might be valuable to determine how much use students make of the Internet as a medium in searching for information on career planning and management. A survey among industry members may also provide valuable insight into how they believe the skills shortages should be addressed and what their perceptions on career management strategies are.

Future research needs to mine deeper into the impact of Black Economic Empowerment considerations on the career perceptions of South African students, because the reality is that BEE can affect the careers of the nation. It may also be worthwhile to investigate the impact of affirmative action on individuals' career goals, perceptions and management. Further research based on this study could be conducted to determine what differences students perceive in the private-sector and public-sector job markets, as well as what influence government has on their future career choices and goals.

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The individual inventor and the implications for innovation and entrepreneurship

A view from Wales

Brychan Thomas, Lynne Gornall, Gary Packham and Christopher Miller

Abstract: *This paper investigates, through quantitative and qualitative analysis, inventive activity in the modern technological setting of Wales in the 21st century. The paper reports on the barriers, motivations and drivers to inventors becoming entrepreneurs in exploiting their ideas and taking them to market, and indicates the outcomes of a pilot phase of the Wales Inventors' Questionnaire (WIQ). The paper concludes by considering some of the barriers, motivations and drivers faced by the inventors – both those suggested by inventors themselves and those reported in the academic literature – and possible ways of overcoming difficulties. From the findings, it is proposed that there is more to the inventive process than the barriers, motivations and drivers observed and that personal characteristics may inhibit or inspire the individual inventor.*

Keywords: *inventor; innovation; entrepreneurship; peripheral regions; Wales*

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Invention and entrepreneurship are two different activities although the same person may be involved with both. An inventor, for example, will develop a new product or service, but may not bring it to market. An entrepreneur will take the risk of bringing together resources to take the product or service to market in the hope of making a profit (Hart *et al*, 1995; Gallagher and Hopkins, 1999). Clearly, the entrepreneur may not have been the inventor, and indeed, not all inventors are entrepreneurs. An 'innovation' will use an invention in

Table 1. Inputs and outputs of inventive work.

Process	Inventive inputs		Inventive outputs	
	Feedback inputs	**Other inputs**	**Feedback outputs**	**Other outputs**
Inventive work	Orders from entrepreneurs Inventive work development	Outputs of research	New technological problems Unexplainable successes and failures	Patents Non-patentable inventions

Source: adapted from Ames (1961) and Freeman and Soete (1997).

and Soete (1997), there was a shift towards large-scale corporate research and development. This is contrary to the interpretation expounded by Jewkes *et al* (1969) in their classic study, *The Sources of Invention*, as mentioned above, who play down the difference between the nineteenth and twentieth centuries and minimize the importance of corporate R&D. Moreover, they argued that important twentieth century inventions were attributable to individual inventors, as in the nineteenth century – inventors 'freelancing' or working in universities. Jewkes *et al* do, however, concede that, due to the huge development costs, large-scale corporations will be necessary to bring inventions to commercial exploitation. Indeed, of 64 major twentieth century inventions, 40 were attributable to individual inventors and 24 to corporate R&D; but half of those attributable to individual inventors were dependent on large firms for commercial development.

Freeman and Soete (1997) maintained from the standpoint of economics that it was *innovation* that was of central interest, rather than *invention* – although they did not deny the importance of invention or the vital contribution creative individuals make to invention. Johnson (1975) recognized the economic significance of invention in terms of its process and relationship to the size of the firm and the role of the individual inventor. In fact, Freeman and Soete (1997) see no inconsistency between Jewkes *et al*'s emphasis on the importance of university research and invention and the interpretation they give. (The interaction of the inventor with universities has more recently been noted by Agrawal (2001) in the context of university-to-industry knowledge transfer). Nor do Freeman and Soete deny that the 'lone wolf' and the 'inventor–entrepreneur' still play an important role; but they do note that, even with respect to Jewkes *et al*'s account of major inventions, there was a shift beginning early in the twentieth century to a larger contribution from inventors associated with corporate R&D; in this account, a new pattern thus began to emerge in the twentieth century in which the role of the inventor–entrepreneur became less important. While the UK may have been perceived as a nation of inventors (HM Treasury, 2004), it appears that the only way to be commercially successful today is to be an 'entrepreneurial inventor' (Nicholas, 2003).

According to Freeman and Soete (1997, p 169),

> '. . . the test of successful entrepreneurship and good management is the capacity to link together . . . technical and market possibilities . . . Innovation is a coupling process and the coupling first takes place in the minds of imaginative people . . . But once the idea has ''clicked'' in the mind of the inventor or entrepreneur, there is still a long way to go before it becomes a successful innovation . . . The one-man inventor–entrepreneur . . . may very much simplify this process in the early stages of a new innovating firm, but in the later stages and in any established firm the ''coupling'' process involves linking and co-ordinating different sections, departments and individuals.'

The individual inventor

A fundamental question regarding the role of the individual inventor is whether or not invention depends on individual inventors in terms of national and regional policies, which may aim to liberate individual 'inventiveness'. This is debatable since, although most inventions are promulgated by individuals, in that a creative idea emerges from one person, it is possible for two or more people to come together to formulate the idea. This is contrary to Norris and Vaizey's (1973, p 36) assertion that 'groups of people do not tend to produce creative ideas'. There is thus the possibility of co-invention, and this notion is supported by the research reported in this paper and enunciated in the survey of inventors, which provides evidence of inventors working together in a number of cases. Nevertheless, although inventors may work together, it is still the case that many will be individual inventors.

This proposition leads to various possibilities regarding invention. Not only will there be individual and co-inventors; there will also be 'serial' inventors

and Vaizey (1973) note that inventions can be the result either of many highly trained people working together methodically with considerable financial backing or of an individual's endeavours, and surmise that the individual inventor will continue to play a significant role.

According to Spence (1995), the word 'innovation' is often used to indicate something new, created or produced, and is commonly confused with invention. However, while inventions can be seen as innovations because they are new, innovations are not necessarily inventions. Spence (1995) points out that innovations may be new applications of long-established ideas, products or services. An interesting development of the classic distinction between innovation and invention relates to technical novelties (McKelvey, 1997). These may be hidden in an inventor's garage or under examination in a corporate R&D department. They may also be mentioned in patents but remain unused, developed or sold, in which case they are technical inventions. As technical novelties they include a combination of techniques, knowledge and technology. In fact, inventions become innovations when they are used for marketable products or are sold. Indeed, an innovation will have a degree of technical novelty and will involve interaction with the marketplace.

An interesting concept is 'collective invention', which is 'the free exchange of information about new techniques and plant designs among actual and potential competitors' (Foray, 1997). This has been described with reference to the iron industry:

> 'If a firm constructed a new plant of novel design and that plant proved to have lower costs than other plants, these facts were made available to other firms in the industry and to potential entrants. The next firm constructing a new plant could build on the experience of the first by introducing and extending the design change that had proved profitable. The operating characteristics of this second plant would then also be made available to potential investors. In this way fruitful lines of technical advance were identified and pursued.' (Allen, 1983, p 2.)

It is through such behaviour that cumulative advance occurs (Ehrnberg and Jacobsson, 1997).

It appears that individual entrepreneurship has become less important and collective entrepreneurship more important (Edquist and Johnson, 1997). This applies to the individual and co-invention explored in the Wales Inventors' Questionnaire (WIQ) described below. Radosevic (1997) uses 'enterprization' to describe the process of building complete enterprises instead of production units (Jacobsson, 1997) – the term was originally coined by Bornsel (1994). The proposition of the research described here, therefore, is that, in addition to the explicit factors involved in the process of individual invention described in the literature, there are also implicit factors, including personal characteristics. This proposition is explored in the Welsh context.

Research methodology

The data for the study were gathered through a structured questionnaire with twenty-one questions (Appendix) which was distributed to fifty-five inventors who were participants at two meetings held in Industrial South Wales. As far as the researchers were aware, no previous research had been undertaken into the activities of inventors in Wales. A structured questionnaire involving the use (and rejection) of apposite classification questions/types was chosen in order to achieve a high response rate from the sample – thirty-three completed questionnaires were received (60% response rate) (CRS, 2006). Although questionnaires involving small samples produce less impressive reliabilities, they can provide the basis for an acceptable and realistic interpretation of overall opinion for small population sizes (Kirakowski, 2000) and, given the difficulty of gathering inventors together at the same time, it was felt that the groups were reasonably representative of individual inventors in Wales. The structured questionnaire was also deemed appropriate for the inventor respondents, who had limited time available (Leung, 2007). The meetings were held by the Valleys Innovation Partnership, in conjunction with Business Connect and Know-How Wales. Inventors and companies were invited with the intention of introducing inventions into businesses in the short to medium term.

The questionnaire was distributed towards the end of the meetings and inventors were asked to complete it and hand it in on the spot or return it by post. Based on the findings from the review of the literature emphasizing the importance of inventions and inventors (Jewkes *et al*, 1969; Freeman and Soete, 1997), the questionnaire was divided into two sections: Section A, 'The Invention', designed to explore explicit factors, and Section B, 'The Inventor', designed to investigate implicit factors (see Appendix). The principal findings are reported below.

Results

In accordance with the research methodology and questionnaire design the findings are reported according to the two main areas investigated, involving respectively the invention and the inventor.

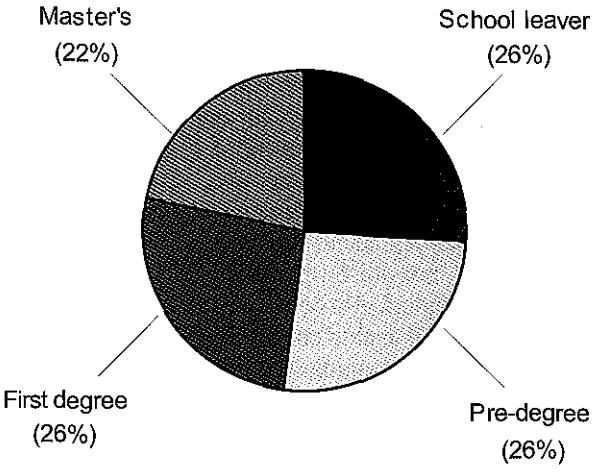

Figure 4. Educational qualifications of inventors.

for a patent as opposed to other IP protection but, because of the processes involved (illustrated by the 14% difference between those using a patent lawyer and those actually filing a patent), may not follow through on the attempt. The survey focused on patenting rather than on other forms of IP protection as the literature review indicated that patents were the main form of protection sought. In addition, 30% of the respondents said that they had received funding for their invention and 70% said they had not.

The inventor

The findings concerning the inventor are reported below according to inventor status (including educational qualifications), inventive activity, motives, personal characteristics, and links with educational and support organizations (see Appendix).

Inventor status. Sixty per cent of the inventors reported that they were sole inventors and 40% that they were joint inventors. Ninety per cent were male and 10% female. With respect to employment status, 46% were employed, 18% were self-employed, 32% had retired and 4% fell into 'other' categories.

The educational qualifications of the inventors are summarized in Figure 4, which shows that 26% were school leavers, 26% were pre-degree, 26% had a first degree and 22% had a Master's degree. Of the joint inventors, 14% were school leavers, 14% were pre-degree, 58% had a degree and 14% had a Master's degree. Thus 48% had either a first degree or a Master's; this is similar to the findings of Schmookler (1957, 1966), who noted that 50% of inventors in his sample were college graduates.

Inventive activity. About 33% of the inventors reported that their invention was related to their work or business, while 67% said that this was not the case. Similarly, 67% reported that their invention related to their domestic life or a hobby. Thirty-eight per cent of the inventors reported no previous inventive activity, 17% reported one previous invention, 7% two previous inventions and 38% several previous inventions. Previous inventions included electronic or electromechanical devices, an invention related to nickel pellets analysis, an artificial golf mat, a medical device, children's interactive software, an exercise chair, a baby beaker, a one-person operated water level, and ultrasonic bonding.

Motives. The motives for invention included the need to find a solution to a technical problem, a project of interest, a remedy, a hobby, profit, the desire to develop something new, a personal need and the desire to improve a product. Ten per cent of the inventors said their motivation had changed as the invention had developed; 90% said their motivation had not changed. This finding relates to the innovation development process, involving key motivations that are affected by personal characteristics.

Personal characteristics. The personal characteristics that the respondents felt had helped their inventive activities included: 'persistence', 'well-developed problem solving mind', 'obtuse thinking', 'simplification', 'innovative', 'entrepreneurial', 'perseverance', 'improvement', 'inquisitive', 'creative', 'curiosity', 'engineering background', 'drive', 'energy', 'good imagination', 'tenacity', 'optimism', 'opportunistic', 'patience', 'dexterity' and 'concentration'. Asked whether they would invent again, 92% said that they would; among the reasons given were that it was what they did, that it gave them a 'nice feeling' and that they enjoyed the challenge.

Links with educational and support organizations. Surprisingly, 77% of the inventors had no links with a university or college to aid their invention. About a quarter of them had been aware of government-backed support. The least-known support organizations were the Chamber of Commerce and private consultants (and a small percentage said that they would not use support from these organizations, or from patent lawyers).

Discussion

The results from the initial study and analysis reveal a broad spread of ideas. This mirrors general inventive activity at national (Burns, 2007) and international (Freeman and Soete, 1997) levels, where all manner of ideas are in evidence. About three-quarters of the inventions in the survey took place in the late 1990s

its novelty, patentability and market potential. If the evaluation is positive, the invention can be developed and protected through the filing of a patent application and the drafting of a development and commercialization strategy.

In considering the barriers, motivations and drivers faced by the inventors in the survey, possible ways emerge of overcoming problems by enabling them to become involved in entrepreneurial activities. These methods are being investigated by the Centre for Enterprise at the University of Glamorgan. Key barriers to inventive activities appeared to be the cost of applying for a patent and the need for finance, and key motivations included being inquisitive, creative and curious, and having drive, energy and a good imagination. The findings thus suggest that, in addition to the explicit factors in the success of the individual inventor, there are implicit factors such as personal characteristics. We also contend that, to develop an invention in a peripheral region such as Wales, there is a need for a 'coupling' process between invention and entrepreneurship. In fact, the individual inventor has been identified by the Welsh Assembly Government as an important actor in the commercialization of science in its determinations on a 'Science Policy for Wales' (WAG, 2006a; 2006b).

The question arises as to whether policy makers should leave inventors alone, and let market forces take effect, or intervene. On the evidence gathered by the Wales Inventors Questionnaire (WIQ) (Gornall and Thomas, 2001), it appears that intervention is appropriate, given the specific requirements of many individual inventors and their need for support (Meyer, 2005). This problem is not exclusive to Wales and seems to exist in most economies. The harnessing of peripheral individual talent through the coupling process can yield as yet unrealized benefits to the economic development of regions and countries. This study clearly suggests that strategies need to be formulated to exploit such indigenous talent, but larger studies are needed to shape the future political strategies of our knowledge economies.

With regard to the specific initial research reported here, we plan to develop our findings through further investigation into the individual inventor in Wales and his or her role in innovation networks (Pickernell *et al*, 2009) with a view to reinforcing our conclusions and recommendations.

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SECTION A: THE INVENTION

1. Can you indicate a general title for your invention?
2. Please give a brief description of your invention.
3. In what year did your invention take place?
4. When did you first register your invention (*please tick one box only*)?

☐ Within one year of the invention taking place
☐ Two to three years of the invention taking place
☐ Three to five years of the invention taking place
☐ Five to ten years of the invention taking place

Please elaborate on the process of invention.

5. What activities, if any, took place prior to the invention (*please tick as many boxes as applicable*)?

☐ Research or exploring information
☐ Planning
☐ Assessment
☐ Testing
☐ Other (please specify)

Please give brief details of the activities that took place.

6. Who do you think your invention would benefit (eg domestic, industrial, education sectors)?

What would be the main benefits to users?

7. Have you applied for a patent for your invention?

☐ Yes
☐ No

8. If YES, did you do this through a patent lawyer?

☐ Yes
☐ No

9. If YES, has the patent been filed?

☐ Yes
☐ No

10. Have you received any sources of funding or finance for your invention?

☐ Yes
☐ No

If YES, what have these been?

SECTION B: THE INVENTOR

1. Can you tell us something about yourself as an inventor?
What is your current inventor status (*please tick one box only*)?

☐ Sole inventor
☐ Joint inventor
☐ Other (please specify)

Are you:

☐ Male
☐ Female

11. Which of the following types of support are you aware of, or have you used, during the last five years (*please tick appropriate boxes*)?

	Aware of profession/ organization	Aware of support	Have used support	Would use support	Would not use support
Patent lawyer					
Private consultant					
Chamber of Commerce					
WDA					
Local authority					
Business Connect					
Enterprise agency					
TEC					
University					
Further Education College					
Other (please specify)					

The University of Glamorgan and the Valleys Innovation Partnership are trying to bring inventors and support agencies together. Please hand in your survey form or post it. Please give details of other inventors who would be interested in completing this questionnaire. Thank you.

Diverse enterprising needs and outcomes: a case for experiential learning

Nirmala Dorasamy

Abstract: *Fundamental changes in how economies function and how organizations are structured and managed in a global environment have created a new imperative for enterprise education. Higher education has to concern itself with appropriate and effective programmes that develop enterprising graduates in an endeavour to drive forward a knowledge-based enterprising society. This paper explores the complexities associated with enterprise education provision which have influenced the emergence of diverse theories and diverse meanings. Given the diverse nature of enterprise education and the absence of a definite conceptual framework, it can be argued that higher education has to address a plethora of challenges to satisfy the different expectations of government, business and students within a global context while noting that these expectations can be conflicting. Apart from varied and conflicting expectations, broad interpretations of enterprise education add to the diversity of outcomes. The plausibility of reconciling different expectations for enterprise education has hindered its wider applicability and general consensual value. This paper makes a case for the use of an experiential learning model to adapt and amend learning outcomes for different purposes and priorities while not losing sight of the essence of being enterprising. The final section outlines briefly how the practice of experiential learning at Durban University of Technology attempts to address the challenges of enterprise education.*

Keywords: *diversity; enterprise education; enterprising outcomes; experiential learning; South Africa*

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Fundamental changes in how economies function and how organizations are structured and managed have created a new imperative for enterprise education. Enterprise education has to develop individuals with both general and specific skills and knowledge as well as the ability to engage in innovative activity. Broad interpretations of being 'enterprising' include the ability to take initiative and responsibility and to lead; it embodies personal qualities like creativity, flexibility and adaptability. In many states enterprise education has become part of educational policy, with programmes aiming to prepare students for a world where they will increasingly need to manage their careers and lives in an enterprising way. It cannot be assumed that the teaching

economic pressures and enable them to acquire career-related knowledge and skills (Anderson and Jack, 2008).

There is ongoing debate as to whether higher education institutions can make a significant contribution to the production of enterprising graduates. Johannison (1991, in Matlay, 2008) claims that it is beyond the capabilities of the academic, in terms of both time and scope, to teach individuals to become enterprising. Rae (1997, in Matlay, 2008) argues that the traditionally taught skills are still essential but insufficient in themselves. Given these different perspectives, the diversity of programmes has been matched by a growing rhetoric that demands more and better programmes (Solomon *et al*, 2002, in Matlay, 2008). The rationale for enterprise education is powerful – it can help to sustain economies and produce prosperity – but the challenge of addressing the critical issues remains.

Challenges facing enterprise education

The growing literature on the development of enterprise education reflects the widespread recognition of its potential positive impact. However, the complexities inherent in its provision and its role in developing enterprising graduates have been inadequately researched (Matlay, 2008). Different meanings, divergent theories and contextual difficulties have hindered the wider applicability and general consensual value of enterprise education. While some commentators argue in favour of a common definitional model, others conclude that a single model is unlikely to address the heterogeneity associated with enterprising practice (Matlay, 2008, p 1). In the absence of a common understanding of contextual and conceptual difficulties, as well as of a platform to compare outcomes of such educational programmes, developing enterprising graduates becomes problematic.

There are differing perceptions of the contribution of enterprise education to the development of enterprising graduates. Some authors argue that enterprise education, or important aspects of it, can be taught before, during and after the initiation of enterprising activities, while Johannison (in Matlay, 2008) claims that to teach students to become enterprising and business-minded is beyond the potential of an 'academic business school'. In the absence of an overarching conceptual framework, and because of the varied expectations of enterprise education outcomes, divergent and heterogeneous programmes proliferate. Given the growing demand for such educational programmes, the focus should be on their content and methodology and not on whether or not the subject can be taught.

Outhwaite (1986, in Jack and Anderson, 1999) maintains that 'positivist' knowledge, which yields a methodologically unified and hierarchical conception of service, is neither judgemental nor based on perception. Enterprising knowledge is, on the other hand, anti-positivist (Johannison, 1992, in Matlay, 2008), requiring creativity in dealing with judgemental decisions and the unknowable nature of enterprise (Jack and Anderson, 1999). From an educational perspective, there are limitations in dealing with the unknown nature of what it means to be enterprising and the associated subjectivity of problems (Jack and Anderson, 1999). Consequently, if being enterprising is unpredictable and the result of complex and contingent variables, then analysing and teaching actions whose nature has not been fully determined is a difficult task (Jack and Anderson, 1999). It would be worth exploring how educational institutions are addressing this challenge.

While skills development is effective in active learning, issues associated with assessing skills in student-centred learning can be problematic (Hartshorn and Hannon, 2005). Qualities such as adaptability, flexibility and open-mindedness are not commonly defined or measured. Furthermore, developing students' multidisciplinary capabilities and complex analytical skills cannot be limited to a timeframe: over time, other factors outside the programme can impact on the achievement of those skills. Herein lies the dilemma of determining which skills should be developed, to what level they should be developed and whether their achievement can be effectively validated over time.

While the acquisition and development of relevant skills builds students' enterprising capacity, Jack and Anderson (1999) note that the application of skills is always contextual and enterprising activities also involve interpersonal skills. The diversity of skills required heightens the difficulty of determining the nature of specific skills to be imparted and the knowledge content of a particular course. Skill sets seen as important in particular contexts contain different combinations of skills, have different purposes and are based on different definitions and interpretations. Determining the appropriate skills mix can be problematic, given varying needs and the continuous change affecting enterprise education, especially if teaching enterprising skills is seen as an art (Jack *et al*, 1999, in Edwards and Muir, 2005). Different skills are emphasized in different programmes and thus there are different learning outcomes. There is a therefore a danger that the continuous adaptation of learning outcomes for different purposes and priorities will lose sight of the essence of enterprise education.

what the learner has actually learned. Measurement systems need to be developed to validate a broad range of learning outcomes, given the wide spectrum of enterprise education.

The general approach to enterprise education reflects the conceptual confusion as to what actually constitutes it. It is difficult to define precisely what enterprise education is, what it aims to do and what may be achieved through it (Hytti and O'Gorman, 2004). The distinctiveness of enterprise education is being blurred because of its overlap with other concepts, such as work-related learning and entrepreneurial learning. Hytti *et al* (2004) attribute conceptual confusion to the diverse goals or different possibilities that enterprise education offers. They argue that a clear understanding of the objectives of such educational interventions is a prerequisite in designing effective programmes.

The challenge is that the varying demands for enterprise education present different, sometimes incompatible expectations with regard to its outcomes. Different skills, abilities and knowledge are required to fulfil those diverse demands (Anderson and Jack, 2008), leading to different notions of what is important and for whom and when it is valued, and thus to conflicting conceptions of what enterprise education is (Hannon, 2006, in Anderson and Jack, 2008).

In the absence of a broadly-accepted outcomes benchmark, determining the primary deliverables for enterprising provision across the curriculum becomes arbitrary. Determining which outcomes should be the primary focus, or the range of outcomes that should be included, could significantly enhance the effectiveness of enterprise education programmes.

Given that the goals of enterprise education vary, the most obvious learning outcomes are not always the most appropriate. Outcomes must be determined in accordance with educational level, the goals of the programme and the target audience, all of which need to be clearly identified (Bechard and Toulouse, 1998, in Fayolle *et al*, 2006). Enterprise education is challenged to develop diverse competences in response to diverse needs: how far this can be achieved is a matter of debate.

Theory produces critical awareness while skills development gives meaning to students' knowledge. Students need academic knowledge as a basis for their experience of enterprise. Academic knowledge, both conceptual and analytical, can be integrated into experiential learning. According to Robinson and Haynes (in Jack and Anderson, 1999), an area that needs to be addressed is the linking of academic learning to the 'real world'. While the educational paradigm of learning by doing has wide support, its success is dependent on the mastery of theory. This is supported by Leinhardt *et al* (1995, in Bennett *et al*, 1999), who argue that integrating knowledge learned in the academy with knowledge learned in practice is a complex task and it is not clear how such integration can be accomplished. If that integration is not achieved, the knowledge acquired can remain isolated and inert. Anderson and Jack (2008) add that many years of research have failed to identify the composition of the specialized knowledge required for enterprise education: the knowledge required in an enterprising context, they argue, is theoretical and so the ability to apply abstract knowledge to a practical context is essential. Kirby (2004) highlights the need to change the purpose and focus of learning, moving away from traditional learning modes and promoting learning through active participation, with practical experience reinforced by enterprising knowledge. That knowledge, for example, gives students theoretical explanations of why certain enterprising graduates succeed: enterprise education can be superficial if the students are not adequately taught the theory behind the practice.

The complex and multidisciplinary nature of enterprise education, then, requires an integrated approach which will equip graduates with such advantages as visionary thinking, flexibility and a global perspective (Wright *et al*, 1994, in Walker *et al*, 1998). The identification of learning outcomes needs to focus on the cross-functional and cross-disciplinary knowledge and skills that have been developed. Walker *et al* (1998) note that discipline-specific content inhibits the development of cross-functional and multidisciplinary skills and the inculcation of the attitudes that are appropriate in a global economy.

The demarcation between skills and knowledge is problematic when skills are seen as the business of vocational education while knowledge is seen as the primary objective of academic study. Corrigan *et al* (1995) argue that the cognitive skills that students are expected to develop, including knowledge, interpretation, application and analysis, transcend the academic and vocational divide. Developing key skills, such as enterprise, creativity and innovative ability, encourages students to identify opportunities and provides them with the knowledge and skills to exploit those opportunities (Jack and Anderson, 1999). It is clear that a focus on the integration of skills and knowledge rather than on their distinctiveness, is crucial for effective enterprise education.

Enterprising skills such as creativity, flexibility and innovative ability are highly subjective and inductive. These skills are fundamentally experiential. Individual performance is also influenced by different levels of strength and competence in different skills. Although the establishment of a systematic approach to

order to develop related skills and self-awareness and to understand the application of skills in new settings.

Conclusion

Students need a coherent blend of knowledge and skills in and across programmes to prepare them for an enterprising world. They must be able not only to acquire and assimilate knowledge but also to manage and apply knowledge in action. Issues such as the relevance of curriculum content, the balance between theoretical knowledge and practical skills, the significance of cross-disciplinary integration, the appropriate mix of skills and how best to develop students in critical thinking are still widely debated. The integration of enterprise education into higher education programmes carries with it multiple purposes and objectives. Programmes that respond to individual, social and global needs require appropriately designed content, mixed pedagogical approaches and well-trained teachers. Any attempt to acquire an enhanced understanding of enterprising practice must involve the conceptualization and development of models of the enterprise knowledge and skills necessary to develop enterprising graduates. Oates (1990, in Bennett, 1999) argued that such a framework must be accompanied by a clear identification of function, a firm theoretical base and appropriate empirical evidence. These criteria are crucial for effective enterprise education, and higher education must now embrace enterprise education if it is to fulfil its role of developing enterprising graduates who can effectively apply the skills and knowledge they have acquired.

For the broad spectrum of enterprise education, there is a need to identify desirable outcomes. The need to agree and implement a common understanding of those outcomes is essential for effective enterprise education, and the resulting framework of outcomes needs to be articulated and widely applied. For this to be achieved, there needs to be more rigorous support for enterprise education across higher education institutions in response to the pressures of globalization.

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Calendar

This calendar of events is based on information provided by the respective organizers and from secondary sources. INDUSTRY & HIGHER EDUCATION welcomes information on meetings suitable for listing in this section. Copy deadlines are three months ahead of cover dates.

3–6 November 2009, Liverpool, UK
32nd Institute for Small Business & Entrepreneurship (ISBE) Conference. Contact: Liz Carrington, Business Development and Events Manager, ISBE, 137 Euston Road, London NW1 2AA, UK. E-mail: liz@isbe.org.uk. Website: www.isbe.org.uk.

19–20 November 2009, Budapest, Hungary
RENT XXIII – Research in Entrepreneurship and Small Business. Contact: European Institute for Advanced Studies in Management, place de Brouckère-Plein 31, 1000 Brussels, Belgium. Tel:+32 22266660. Fax:+32 25121929.

25 November 2009, London, UK
Universities UK Conference. Theme: 'Creating a higher vision – the HE contribution to the creative economy'. Contact: Catriona Coyle, Universities UK, Woburn House, 20 Tavistock Square, London WC1H 9HQ, UK. E-mail: events@universitiesuk.ac.uk.

29 November–2 December 2009, Brisbane, Australia
ISBC 2009. 36th International Small Business Congress. Theme: 'Small business reaching out'. Contact: Event Planners Australia, PO Box 1517, Eagle Farm, QLD 4009, Australia. E-mail: info@isbc2009.org. Website: www.isbc2009.org.

1–3 December 2009, Belfast, Northern Ireland, UK
BI 11. Annual Conference of UKBI (UK Business Incubation). Theme:'Driving forward economic recovery'. Contact: Faye Busby at f.busby@ukbi.co.uk. Website: www.ukbiconference.co.uk.

6–8 December 2009, Riga, Latvia
Conference on Higher Education Spaces and Places for Learning, Innovation and Knowledge Exchange. Contact: University of Latvia, Raina bulov 19, Riga, Latvia. E-mail: cele@lu.lv. Website: www.oecd.lu.lv.

8–10 December 2009, Newport, UK
Annual Conference of the Society for Research into Higher Education. Theme: 'Challenging higher education – knowledge, policy and practice'. Contact: Francois Smit at srheconferenceteam@srhe.ac.uk. Website: www.srhe.ac.uk/conference2009.

3–5 February 2010, Palm Springs, CA, USA
2010 Conference for Industry and Education Collaboration (CIEC). Theme: 'Preparing the workforce for the global marketplace'. Contact: Paul Villeneue (Conference Chair), University of Maine, 5708 Barrows Hall, Room 9, Orono, ME 04469–5708, USA. E-mail: paul@eece.maine.edu.

18–20 March 2010, New Orleans, LA, USA
Annual Meeting of the Association of University Technology Licensing Managers. Theme: 'Building a stronger community'. Contact: Aaron Adair, E-mail: aadair@autm.net. Website: www.autm.net.

24–26 March 2010, Charlotte, NC, USA
Sixth Annual Forum on Education Abroad Conference. Theme: 'Vision and value in education abroad'. Contact: Forum on Education Abroad, Dickinson College, PO Box 1773, Carlisle, PA 17103, USA. Tel: +1717 245 1031. E-mail: infor@forumkea.org. Website: www.forumea.org.

24–26 March 2010, London, UK
Going Global 4. Theme: 'World potential – making education meet the challenge'. Contact: Going Global Team, The British Council, Bridgewater House, 58 Whitworth Street, Manchester M1 6BB, UK. Tel:+44 20 7389 4040. E-mail: going-global@britishcouncil.org. Website: www.britishcouncil.org/goingglobal.

20–21 May 2010, Bradford, UK
Engage HEI Conference 2010. Themes: 'The nature and process of open innovation and knowledge exchange'; 'The utilization of social capital to facilitate open innovation and knowledge exchange'; 'The regional policy perspective'. Contact: Dr Nigel Lockett, Centre for Entrepreneurship and Innovation Management, Bradford University School of Management, Emm Lane, Bradford BD9 4JL, UK. E-mail: n.j.lockett@bradford.ac.uk. Website: www.engagehei.org/2010_conference.html.

20–23 June 2010, Louisville, KY, USA
2010 Annual Conference and Exposition of the American Society for Engineering Education (ASEE). Contact: Leigh Ann Watson, Meetings and Registration Manager, ASEE. E-mail: l.watson@asee.org.

21–24 July 2010, Paris, France
2nd Paris International Conference on Education, Economy & Society. E-mail: paris-conference@analytics.org. Website: http://education-conferences.org.

3–4 August 2010, Banff, Canada
Diana International Conference on Women's Entrepreneurship Research. Theme: 'Extending women's entrepreneurship scholarship in new directions'. Contact: Jennifer Jennings at jennifer.jennings@ualberta.ca or Karen Hughes at karen.hughes@ualberta.ca. Website: www.business.ualberta.ca/conferences/dianainternationalconference.

Notes for authors

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Type and length of contributions

The major part of the journal is taken up by papers between 4,000 and 8,000 words long. These should be analytical and evaluative in approach and not simply descriptive. Other contributions include opinion or 'viewpoint' pieces (1,500–3,000 words), case studies of specific ventures or programmes (1,500–3,000 words); brief factual summaries of reports, agency programmes, educational institutions, etc (1,000–2,000 words); and letters to the editors.

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Submissions should be double-spaced. They can be sent either by e-mail to the editor at jedmondip@aol.com or by post (in which case two hard copies and a disk should be enclosed). Papers should preferably be sent in Word (please note that PDF versions are not acceptable for review purposes). The *title page* should contain full names of the authors, their professional status or affiliation, and the address to which they wish correspondence to be sent. There should be an *abstract* of about 100 words at the beginning of the paper. The text should be organized under appropriate *cross-headings* and where possible these should not be more than 800 words apart.

Between 3 and 6 *keywords* should appear below the abstract, highlighting the main topics of the paper.

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- *Articles:* Collins, Steven W. (2001), 'Academic research and regional innovation: insights from Seattle, Washington', *Industry and Higher Education*, Vol 15, No 3, pp 217–221.
- *Books:* Roberts, E.B., ed (1991), *Entrepreneurs in High Technology*, Oxford University Press, Oxford.

Notes should be numbered consecutively in the text and typed in plain text at the end of the paper (not as footnotes on text pages).

Figures and tables should be presented separately on separate sheets at the end of the text. Each figure or table must be referred to in the text – the first reference will be used to locate the figure or table in the final printed version.

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Lueddeke, G. (2003), 'Professional teaching practice in higher education: a study of disciplinary variation and "teaching–scholarship"', *Studies in Higher Education*, Vol 28, No 2, pp 213–228.
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developing individual specified outcomes for skills-based learning is an important consideration, this further adds to the complexity and diversity of enterprise education provision.

Apart from subject-specific knowledge, understanding and skills and their integration with other disciplines, enterprising graduates also need transferable or generic skills. These skills are applicable to any discipline and to a range of contexts. Relch (1991, in Kothari *et al*, 2007) advocates the development of 'symbolic analysts', who can combine the relevant disciplinary understanding and skills with the generic skills that are needed for effective enterprise education.

Internationally, the diversity of responses to the enterprising imperative in higher education increases the difficulty of measuring the effectiveness of enterprise education. Given the complexity of the interlinked environments and expectations in which higher education operates, a quality assessment of enterprise education must take into account the priorities of the different interest groups involved (Harvey and Green, 1993, in Houston, 2008). Bowden and Marton (in Houston, 2008) note the need to develop a richer and more flexible understanding of the world so that there is greater potential for new ways of seeing to evolve without blunting the precision of specialized ways of seeing. Houston (2008) supports this view by arguing that critical thinking about quality not only highlights competing definitions but also helps to expose the taken-for-granted values that shape quality definitions and practices. Viewing enterprise education as a system of interdependent elements working together to achieve a purpose can help towards a coherent conception of quality (Houston, 2008). As a system, enterprise education has characteristics that none of its elements possesses individually. If the elements or relationships change, then enterprise education changes. Adopting a critical systems thinking approach thus necessitates an analysis of predominant assumptions and prescriptions relating to quality.

According to Gibb (1993), higher education institutions must understand the needs of students, so that they can match educational programmes to those needs. Given the processes of global change, students recognize that specific skills and knowledge are insufficient and that they will need to be able to be proactive, to see and respond to problems creatively and autonomously. Such new requirements as these should be reflected in the targeted outcomes of enterprise learning. The academic curriculum is a means through which other capabilities can be developed (Collins *et al*, 2004). A standardized approach to enterprise education is inappropriate in an educational environment that is compelled to be diverse in its approach. Differences that can be observed both in the design of effective programmes and in the measurement of the quality of individual learning are attributable to the diversity of expected learning outcomes.

Enterprise education is required to satisfy the different expectations of government, business and students, which can sometimes be conflicting (Jack and Anderson, 1999). Higher education institutions need to develop an overarching approach which, while addressing the diverse expectations of the different stakeholders, also enables the necessary enterprise learning culture that will lead to knowledge and skills acquisition and maintain the quality of teaching and learning.

Experiential learning at DUT

At the Durban University of Technology (DUT), experiential learning is integrated into all educational programmes as part of the teaching and learning strategy. As a university of technology, the natural focus of DUT is on linking theory with practice through experiential learning.

Formal credit-bearing experiential learning is therefore included in academic programmes. The following practices are used to promote an enterprising culture and track enterprise learning throughout the university:

- *Orientation* – students receive instruction to prepare them for the world of work and the acquisition of life skills.
- *Learning programmes* specify learning criteria and outcomes to guide students and mentors.
- The *placement process* is facilitated by the university through the marketing of experiential learning to the public and private sectors.
- *Monitoring* is undertaken by appropriately qualified and experienced academic staff.
- *Learner guides* outline assessment criteria and procedures.
- The university supports the *industrial work placement of academic staff* so that academics can update their practical skills and keep abreast of new developments.
- *Guest lectures* by workplace mentors.
- Experiential learning is one of the standing items of the *advisory boards* which ensure that programmes continue to be relevant and appropriate to the changing international environment.
- *Quality management principles* are applied for the effective arrangement of cooperative education.
- Students present *personal development plans*, whereby students reflect on their experiences in

'Employability', too, has been subject to many and varied interpretations. Hillard and Pollard (1998, in Pool and Sewell, 2007) view employability as the ability to get and keep fulfilling work, to move self-sufficiently within the labour market and to realize one's potential through sustainable employment. Pool and Sewell (2007) argue that employability involves the possession of a set of skills, knowledge, understanding and personal attributes that make people more likely to choose and secure occupations in which they can be successful and satisfied. Given the demand for employable as well as enterprising graduates, does the graduate need first to be employable and then enterprising, or the other way around? The potential integration of both targets in enterprise education programmes may give rise to a new debate about their distinctiveness in student development. Unless a coherent framework is established for both these elusive concepts – employability and enterprising abilities – target outcomes may suffer from a lack of focus and understanding.

Proponents of theories of situated learning argue that the nature of the situation and content in which knowledge and skills are acquired is likely to influence subsequent knowledge development in other situations and circumstances (Bennett *et al*, 1999). Enterprise education supports learning in which students acquire, develop and use skills in an authentic activity (Brown *et al*, 1989, in Bennett *et al*, 1999), and so has to provide authentic workplace environments or simulations of those environments. It is imperative that enterprise education programmes incorporate this aspect if they are to earn credibility.

It has been suggested that enterprise education challenges the 'academy' in its pursuit of knowledge for its own sake (Macfarlane, 1995). Global pressures, however, have forced academic institutions to respond to practical concerns. If the pursuit of objective knowledge remains the core value of higher education, the typical higher education institution is in reality a teaching community dominated by an academic culture. Enterprising activities require academics to relinquish their 'pure' academic identity: inculcating an enterprise culture among academics requires the recognition that enterprise education is a central rather than a peripheral concern and that it needs to be integrated into the academic ethos.

Changes in approaches to teaching and learning are essential for the development of enterprising graduates. Academic staff must be reoriented to learner-centred approaches to teaching and learning, so that enterprising skills can be developed within specific knowledge contexts. Higher education institutions need to consider the core values that underpin enterprise education, such as innovation, creativity in teaching and learning, the efficacy of learning programmes, effective programme management and flexible learning environments.

Diverse needs highlight a critical challenge for growth in the scope and capability of academics who are leading current and future expansion in enterprise education (Hannon, 2007). Fostering a culture of enterprise education requires academic staff with the skills and experience necessary to teach or facilitate enterprise and to contribute to curriculum development and innovation. According to the European Union, there is insufficient exchange and dissemination of good practice in this regard (Hannon, 2007). Appropriate training would help academics to address the conceptual and pedagogical challenges arising from the formidable array of skills, knowledge, attitudes, experiences and behaviours that need to be taught (Anderson and Jack, 2008), as well as the principles that underlie student learning in an enterprising context.

The development of enterprising graduates requires an approach that transcends traditional and mechanistic education. The implication for teaching is the implementation of a process whereby skills are introduced, practised and assessed, leading to high-quality learning outcomes. Standards for effective teaching practice are crucial, and reflection on good teaching practice continues to be a major challenge.

A related problem is that academics are reluctant to commit more time to new developments in teaching and learning (Lueddeke, 1997). Apart from time-consuming tasks and responsibilities, the higher education culture of supporting research over teaching can also be an obstacle to improving teaching practice for enterprise education. Gubbay (1994, in Bennett *et al*, 1999) points out that many academics see teaching for skills as a distraction from the drive for better research ratings. Volkwein and Carbone (1994, in Lueddeke, 1997) add that there may eventually be a realization that the most powerful university learning environments are those that give equal weight to research and teaching. The development of enterprise education requires academics to appreciate through pedagogical practice how knowledge and skills can be understood, how they can be misunderstood and what constitutes 'understanding' (Laurilliard, 1993, in Lueddeke, 2003).

Entrepreneurial outcomes: diverse and undefined

Learning outcomes are an important starting point for setting standards for the validation and recognition of enterprise education. The focus needs to shift, therefore, from curriculum delivery in an educational setting to

input of developing a student's knowledge base and skills will result in the output of enterprising graduates. Approaches to achieving diverse outcomes require diverse teaching pedagogies which are crucial in addressing varying needs in a dynamic environment.

This paper examines the experiential learning model as an effective approach to the development of enterprising graduates in the effort to drive forward a knowledge-based economy and an enterprising society (Hartshorn and Hannon, 2005). It can be argued that experiential learning helps students to acquire not only knowledge but also skills and attributes that will enable them to adapt to a dynamic environment and to manage future uncertainty. The development of critical students able to cope with high complexity through open-minded learning (Barnett, 2000, in Shiel *et al*, 2005) is essential in an increasingly complex, integrated and interdependent world. In this regard, enterprise can be stimulated by education that emphasizes experiential learning (Cresswell, 1999, in Edwards and Muir, 2005).

Teaching an enterprising curriculum requires a learner-centred approach that enables students to prepare for creating and managing their future learning in a global context, and is also innovative, proactive and analytical in a competitive work environment (Hartshorn and Hannon, 2005). Specific issues relating to the diversity of enterprising outcomes and the implications for enterprise education are discussed below.

Rationale for enterprise education

Higher education has a responsibility to ensure that students graduate with competencies that enable them to work effectively in modern organizations. Working life is about continued learning, skilling and reskilling to stay ahead. Modern society is knowledge-intensive and graduates will increasingly require the corresponding skills. The UK's Dearing Report (Dearing, 1997) stated that the development of key skills such as communication, the use of technology and learning how to learn were necessary outcomes of all higher education programmes. Education thus needs an enterprising dimension to prepare students to thrive in uncertain and unstructured environments. So that it can provide students with innovative learning opportunities that have a real and sustainable impact, enterprise education has to be broad, integrative, pragmatic and rational (Kuratko, 2003).

Enterprise education has progressed beyond the myth that enterprising graduates are born, not made. Drucker (1985, in Kuratko, 2003) noted that students can learn to become enterprising in a dynamic milieu of vision, change and creation. While it has been argued that an enterprising culture develops naturally (Hynes, 1996, in Jack and Anderson, 1999), rapidly developing modern economies demand graduates who can identify opportunities and have the necessary knowledge and skills to capitalize on and manage those opportunities.

The rise of Schumpterian innovation, in which flexible specialization and business re-engineering coupled with individualism are the driving forces (Jack and Anderson, 1999), requires the development of enterprising graduates who espouse technological innovation, are capable of creative thinking, have leadership skills and can adapt readily to changing circumstances. The shift in emphasis from traditional degrees to the validation of competence has challenged higher education to produce such competencies in graduates (Rae, 2000). It has been argued that the development of enterprising graduates through improving students' transferable skills and knowledge and exposing them to the world of work needs to be addressed explicitly in the curriculum. Leckey and McGuigan (1997, in Hytti and O'Gormon, 2004) suggest that this should, as far as possible, be done within the teaching of the discipline studied and not separated from it.

Enterprise education ensures an education system that imparts specific subject skills and knowledge, but at the same time fosters transferable skills and knowledge. It is generally understood that students enter higher education to study a specific discipline in depth, to gain a degree or higher qualification for a good or a better job (Collins *et al*, 2004). Employers still judge graduates on the level of the qualification they have achieved. It is important to recognize this element of graduate employability but, while subject-specific knowledge remains important, it now needs to be accompanied by enterprising skills. It should be noted that, in an environment with no guarantee of job security, the very concept of a job is being replaced by skills that make and keep graduates successful and satisfied (Boyle, 2007). The acquisition of skills and ideas and the ability to learn and adapt to meet changing requirements are increasingly important.

Change in many fields of activity has prompted this increasing demand for enterprising graduates. Progress in international trade, communication and technology has led to new opportunities. New forms of social governance and the growing recognition of citizens' rights have created new challenges. Organizations, which must now be flexible and adaptable to survive, need a workforce with a diverse skills base. Career structures have changed, and jobs for life are a thing of the past. Such major changes have attracted students to educational programmes that can equip them with transferable skills and knowledge as insurance against

☐ Employed
☐ Self-employed
☐ Retired
☐ Other (please specify)

2. What were the educational qualifications of the inventor(s) (*please tick appropriate boxes*)?

	Inventor	Co-inventor 1	Co-inventor 2	Co-inventor 3	Co-inventor 4
School leaver					
With pre-degree qualifications					
With first degree					
With Master's degree					
With PhD					

3. Was the invention related to your work or business?

☐ Yes
☐ No

If YES, please elaborate.

Did it relate to home or a hobby?

☐ Yes
☐ No

4. Have you invented before (*please tick appropriate boxes*)?

☐ No
☐ Once before
☐ Twice before
☐ On a number of occasions

5. If you have invented before, please give a brief description of your previous inventions.
6. What were the motives for your invention?
7. Have these changed as the invention has developed?

☐ Yes
☐ No

8. What do you believe are the personal characteristics that have helped your inventive activities?
9. Would you like to invent again?

☐ Yes
☐ No

Why?

10. Have any links with a university or college aided your invention?
☐ Yes
☐ No

If YES, what were these links?

Were there any other links that helped (eg company, social, organization, friend, family)?

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Appendix

Welsh inventors questionnaire

Name	
Address	
Tel No	
Fax No	
E-mail	

Please note that the information provided by you in this questionnaire will be kept confidential.

and most had been registered. A third of the inventors reported that their invention had arisen from research. About half of the inventions were considered to be of benefit to the industrial sector. Less than a third of the inventors had received some form of funding.

Around two-thirds of the inventors were sole inventors ('individual inventors' according to Jewkes *et al*, 1969) – fewer than half were joint inventors. This indicates that invention does not have to be a solitary activity but can be a collaborative endeavour. Most of the inventors in the survey were male; as noted above, only 10% were women. This, however, may simply reflect the particular groups surveyed as anecdotal evidence suggests a greater percentage of female inventors generally, and in Wales in particular. The contribution of females inventors is illustrated by the British Female Inventors and Innovators Network (BFIIN) through their Annual Conference and Awards, and is to be investigated by the Women's Entrepreneurship Hub at the Centre for Enterprise, University of Glamorgan, with regard to policy and practice for 2010–12 and beyond (Atkinson, 2009).

The employment status of the respondents was distributed between employed, self-employed, retired and a few 'other'. Around a quarter held a Master's degree and roughly another quarter had a first degree. The implication is that education to degree level is a facilitator of invention.

About a third reported that their invention related to their work and two-thirds said it related to the home or to a hobby (this is similar to the distinction made by McKelvey, 1997). There was an even split between those who had not invented before and those who had invented on a number of occasions. The motives for invention included the need to find a solution, the fact that it was a project of interest and the desire to find a remedy. Only a tenth of the inventors reported that their motivation had changed as the invention had developed. Personal characteristics that had helped in inventive activities included persistence, a problem-solving mind, simplification, being innovative and being entrepreneurial. These characteristics appeared to be the most important in determining a propensity to invent. Most said they would invent again and, surprisingly, around three-quarters of them had no links with academic institutions – contrary to the findings of Agrawal (2001).

Conclusions

The fundamental difference between an inventor and an entrepreneur is that an inventor will develop a new product or service but may not take it to market. An entrepreneur, on the other hand, will take the risk of bringing together resources to take a good or service to market with the intention of making a profit (Gallagher and Hopkins, 1999). An entrepreneur may not be an inventor, and not all inventors are entrepreneurs. Innovation is the application of an invention to a use that has economic value: this is what the entrepreneur adds. Inventors design and develop new products and services, and entrepreneurs identify the opportunities (Burns, 2007), take the business risk and accept the challenges. It should also be noted that inventions solve problems and will lead to other inventions.

There are various similarities between the literature on inventive activity and the findings of the survey described in this paper regarding: prior research (Ames, 1961); inventive outputs (Freeman and Soete, 1997); patent activity (Norris and Vaizey, 1973); inventive activities (Kuznets, 1962); and links to universities (Jewkes *et al*, 1969; Agrawal, 2001). Consistent with the literature the most important activity prior to invention was found to be research (Ames, 1961; Freeman and Soete, 1997). Secondly, there is the importance of the inventive outputs (Freeman and Soete, 1997) in the form of patents (Norris and Vaizey, 1973); this was apparent from the survey as 56% of inventors reported that they had applied for a patent while the other 44% appeared to be in the process of compiling an application or were at an earlier stage. Thirdly, the characteristics the inventors felt had helped their inventive activities (Kusznets, 1962) included being innovative and being entrepreneurial, indicating the connection of these activities with invention. Fourthly, 77% had no links with universities, which is recognized in the literature as important (Jewkes *et al*, 1969; Agrwawal, 2001) and demonstrated by areas such as Cambridge in the UK; the absence of such links is one reason why the individual inventor often has problems in developing an invention in a peripheral region. This leads to the importance of providing inventors with the right kind of support once they have evolved their ideas. This can be achieved through a 'coupling' process which links individual inventors to appropriate forms of assistance. Through such a process individual inventors can turn to patent lawyers, private consultants or universities to inquire about patenting and commercialization (Mörch, 2002). These 'bridge' experts and institutions or 'innovation intermediaries' can provide advice on standard contracts and support. The importance of this type of knowledge was recognized in a report by the Heads of Higher Education in Wales entitled *The Impact of the Higher Education Sector on the Welsh Economy* (HHEW, 1997). In such a system, an inventor can choose to disclose confidentially details of his or her invention to receive a professional evaluation of its commercial possibilities –

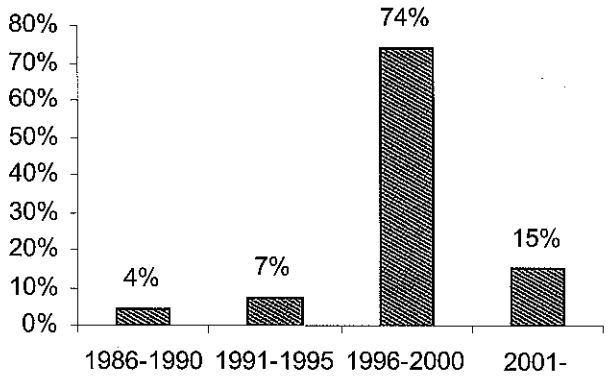

Figure 1. Year of invention.

The invention

The questions asked about the invention are detailed in the Appendix. The 'invention date' and 'activities prior to invention' were ascertained, as described below, and the impact of inventive activities, in terms of the main benefits to users, was considered. The cost barriers and the difficulties of accessing sources of income were also considered in relation to patent applications and the use of patent lawyers and the need for initial sources of income to provide funding or finance for the invention.

Invention date and registration. The distribution of the invention dates (in five-year periods) is shown in Figure 1. The figure shows that 4% of the inventions took place during 1986–90, 7% in 1991–95, 74% in 1996– 2000 and 15% in 2001 or later. Of these 21% were not registered and 79% were registered.

Activities prior to invention. Activities prior to invention included research or the exploration of information,

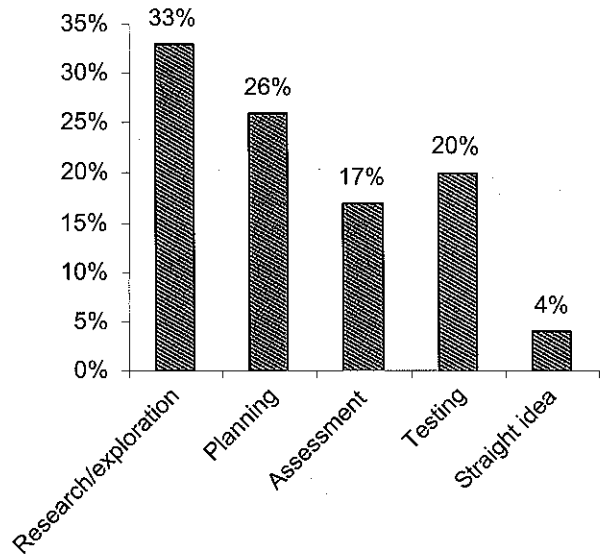

Figure 2. Activities prior to invention.

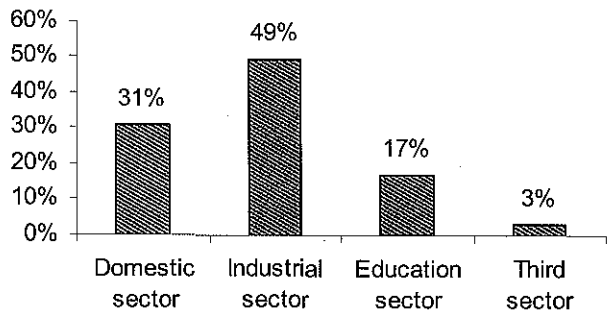

Figure 3. Sectors benefited by inventions (percentage responses).

planning, assessment, testing and a straight idea. Figure 2 provides the percentages for these activities. Most inventions took place in 1996–2000, with the next highest number in 2001 or later: this is unsurprising as most of the inventors attending the meetings at which the questionnaire was distributed would recently have been involved in inventive activities. Most reported that they had registered their invention, as they recognized the importance of this fundamental protection. Registration means that the factual details of an invention are held on record. An example is the World Wide Online Creator's Registry (2009), which provides instant international copyright and intellectual property protection and archiving services. This service provides a certificate of registration and a date stamp. As can be seen from Figure 2, 33% of the respondents said that research or the exploration of information had occurred before the invention, 26% identified planning, 17% assessment, 20% testing and 4% said that it was a straight idea. It is understandable that research or exploration scored the highest percentage, as these activities constitute the fundamental background to many inventions. For this reason, the 'straight idea', the result of inventive flair, scored the lowest percentage: although initially such unproven ideas may promise considerable potential, when investigated in detail many prove to be unworkable.

Main benefits to users. When asked who they thought their invention would benefit, the inventors' responses included the domestic, industrial, education and third sectors. Figure 3 shows that 31% of the respondents thought that their inventions were of benefit to the domestic sector, 49% thought they would benefit the industrial sector, 17% the education sector and 3% the third sector.

Patent applications and sources of funding. About 56% of the inventors had applied for a patent and 44% had not. Some 79% had used a patent lawyer, 21% had not and 65% had filed a patent. A key reason behind these statistics is that an inventor will usually attempt to apply

Table 2. Interrelationships between invention, innovation and entrepreneurship.

Activity/level	Invention	Innovation	Entrepreneurship
Micro	Individual/lone inventor	Innovator	Entrepreneur
SME	Company inventor	Innovation champions	Entrepreneur/ intrapreneur
Large company or organization	Institutional/ corporate inventor	Project champions	Intrapreneur

Source: Thomas and Gornall (2002).

(people who develop one invention after another) and 'parallel' inventors (who develop several ideas at the same time). Exploring the meaning of the phrase 'individual inventor', Norris and Vaizey (1973) suggest that there are two principal types. In the pure sense, an individual inventor is someone who works by himself or herself (otherwise known as the 'lone inventor') – the individual finances the activity and determines the direction of the work. The results remain with the individual at this research stage of the development. This form of inventive activity will probably be carried out on a part-time basis or as the leisure pursuit of someone employed full-time. At the other end of the scale, the corporate or institutional inventor will be a tenured employee working in a specific area, and the results of the inventive activity will be held by the employer. In between these extremes, there are many variations. Between the individual inventor and the corporate inventor, there will be individuals who exhibit characteristics of each: it will be a matter of judgement as to whether or not these are described as 'individual' inventors. The relationships between invention, innovation and entrepreneurship; inventors, innovators and entrepreneurs; and micro-enterprises, small and medium-sized enterprises (SMEs) and large corporations are illustrated in Table 2. There is also a distinction to be drawn between the profit orientation and societal orientation of entrepreneurs and entrepreneurship, but this aspect has been excluded from this study as it constitutes a discrete research investigation in itself.

The measurement of the relative magnitude of inventive activity by inventors is problematic due to the absence of expenditure on this type of activity. Consequently, measurement is based on outcomes: the two main sources of information are patent statistics and details of significant inventions. According to Kuznets (1962), there are four possible dimensions to an invention: its technical and economic magnitude and the past and future. The technical past relates to the magnitude of the technical problem resolved by the invention. Consequently, some inventions are of a greater magnitude than others. The technical future can be measured according to the size of the invention, which is dependent on the inventions that follow. The economic past of an invention involves the cost and is measured according to the resources used. Finally, the economic future of an invention relates to the production of new goods or services, which may enable cost reductions.

Although these measures provide a conceptual framework, the determination of what constitutes a significant or insignificant invention remains in the domain of educated guesswork. In their study of the most important inventions in the twentieth century discussed above, Jewkes *et al* (1969) assembled a list of what were in their judgement the most significant inventions. From their list, there is evidence that, as well as individual inventors, universities and government research laboratories also produced a considerable number of inventions. The reason for the distribution of individual and corporate inventions lies in the factors affecting the individual inventor as a major source of invention, which include time, 'atmosphere', finance and technological resources. The complexities of finding finance facing an inventor are explored by Hobbs (2006) in the context of the inventor–investor relationship.

With regard to time, SMEs will be interested in inventions that will yield a pay-off in the short term and many will expect expenditures to be paid back within five years (Norris and Vaizey, 1973; Freeman and Soete, 1997). This means that, in five years, the firm will expect to recoup its expenditure on research, invention, innovation and marketing, and so the scale of the advancement of knowledge will be restricted. Consequently, most R&D is concerned with small improvements.

In a business context one factor working against invention is the problem of providing the right 'atmosphere'. A major barrier for individual inventors is the lack of finance and this is why they appear to have declined in importance in the twentieth century. Many inventions will require specialized technological equipment, at a cost beyond the reach of many individuals. The role of the individual inventor is therefore likely to be most significant in areas that do not involve expensive technological equipment. Norris

a way that has economic value and this is what an entrepreneur adds. Inventors will design and develop new products and entrepreneurs will recognize the opportunities, take risks in starting new businesses and accept challenges (Freeman and Soete, 1997).

Much has been written about invention and inventive activity and, increasingly in recent years, about the concept of 'entrepreneurship'. Published work typically describes inventive activity on a historical-developmental basis or as a collection of case studies, presenting qualitative findings in relation to the inventive developments taking place. Indeed, the relationship between invention, innovation and entrepreneurship has involved much discussion. Innovation is defined by Kanter (1983) as involving 'creative use as well as original invention' and is simply defined by Mellor (2005) as 'creativity plus application' or 'invention plus application'. According to Porter (1990), 'invention and entrepreneurship are at the heart of national advantage' and Burns (2007) reports that 'invention is the extreme and riskiest form of innovation'. In particular, Bolton and Thompson (2000) highlight creativity in the invention and innovation process and Burns (2007) posits that 'invention can be successfully exploited in the entrepreneurial environment'.

The inter-relationship between invention, innovation and entrepreneurship is of both theoretical and practical significance. It may involve inventors and entrepreneurs in all aspects of the process of product, process or service development, or it may involve them separately. The latter case is exemplified historically by Adam Smith (1776), who observed that 'all the improvements in machinery, however, have by no means been the inventions of those who had occasion to use the machines'. Smith also considered the way the division of labour has promoted specialized inventions. This is articulated by Marx (1858), who notes 'invention then becomes a branch of business, and the application of science to immediate production aims at determining the inventions at the same time as it solicits them'. Freeman and Soete (1997, p 15) develop this theme of invention as 'an essential condition of economic progress and a critical element in the competitive struggle of enterprises and of nation-states', noting that it

> '. . . is of importance not only for increasing the wealth of nations in the narrow sense of increased prosperity, but also in the more fundamental sense of enabling men (and women) to do things which have never been done before at all. It enables the whole quality of life to be changed for better or for worse. It can mean not merely more of the same goods but a pattern of goods and services which has not previously existed, except in the imagination'.

Freeman and Soete (1997, p 16) further remark that 'although most economists have made a deferential nod in the direction of technological change, few have stopped to examine it'. This paradox has been explained by Jewkes *at al* (1969) in terms of economists' ignorance of science and technology, their preoccupation with the trade cycle and employment problems, and limited statistics. Jewkes *et al* (1969) demonstrated this in their study *The Sources of Invention*, and it has been confirmed before and since by empirical studies. Freeman and Soete (1997, p 17) develop this argument concerning the neglect of invention:

> '. . . [it] was not only due to other preoccupations of economists nor to their ignorance of technology; they were also the victims of their own assumptions and commitment to accepted systems of thought. These tended to treat the flow of new knowledge, of inventions . . . as outside the framework of economic models, or more strictly, as ''exogenous variables'' '.

The original distinction between invention and innovation is attributed to Schumpeter (1934, 1961) and has since become part of economic theory. Freeman and Soete (1997, p 22) note in addition, 'an invention is an idea, a sketch or a model for a new improved device, product, process or system. Such inventions may often (not always) be patented but they do not necessarily lead to technical innovations.' They also point out that 'the chain of events from invention or specification to social application is often longer and hazardous' (Freeman and Soete, 1997, p 22). The crucial role of the entrepreneur in this complex process was recognized by Schumpeter (1934, 1961), although he did not consider the study of invention to be of significance in itself. He stressed that the decision of the entrepreneur to commercialize an invention was the decisive step, and defined the entrepreneur as the 'innovator'. A summary of the inputs and outputs of this process, based on Ames (1961) and Freeman and Soete (1997) is presented in Table 1.

In the nineteenth century inventor–entrepreneurs or individual inventors established new firms to develop and exploit processes they had invented or had helped to invent. In fact, during the nineteenth century, and in earlier times, invention would have been carried out in geographical and social isolation, with 'like minds' working on a similar problem (Blaikie, 1993; Naughton, 2007). The significance of the inventor–entrepreneur is noted by Radosevich (1995) and Djokovic and Souitaris (2004). In the twentieth century, according to Freeman

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ensure that they provide graduates with the relevant training and exposure to allow them to 'be good at the job' and thereby enhance their productivity. One way to do this is to offer internship opportunities. Findings from several studies have demonstrated significant early career advantages for students with internship experience, as such experience exposes them to the reality of industry and gives them an indication of what a career in their chosen field of study entails (Gault *et al*, 2000; Callanan and Benzing, 2004). The value of an internship programme lies in it being designed to give student interns exposure to a variety of independent and collaborative work tasks and to the initiation and completion of projects, and to provide them with an opportunity to network with colleagues in an environment where continual feedback on progress and work performance is provided. One local programme that is proving very successful is the Standard Banking Group Internship programme, in which Standard Bank offers two-month internships at undergraduate second-year level (Vala, 2008). This programme gives students business experience by allowing them to solve real business problems. It is also an opportunity for the students to identify their strengths and weaknesses and to decide whether or not financial services is really the field they want to go into. Should they decide that this is not the business for them, the internship has helped them to become work-ready, but more importantly it has equipped them to make improved career decisions before completing their degrees and entering the workforce.

Businesses that do not want to offer internships can always get involved in career days at schools and/or universities. Typical career days can be entertaining occasions when, for example, Grade 7 learners can come to school dressed in an item of clothing representing a career. Such an event can create an interest in careers and career choices at an early age. Industry can also ensure that information on a variety of careers is available at career centres nationwide. Another option is to actively market those jobs for which there are skills shortages. This can be done in enterprising ways, such as providing career guidance and information through roadshows (Matsaneng, 2009). Such shows can take place during school hours in the school hall, where learners get the chance to speak to representatives of different tertiary institutions and employers. Add to this live music and give-aways, and learners will acquire guidelines on career choices in an interactive way.

To address the BEE issue previously mentioned, high-quality education should be offered as a first stepping stone to a potentially better future for individuals, industry and the country. Secondly, a review of affirmative action may be needed. There is no doubt that the previously disadvantaged need to be helped up the ladder, but this should not be achieved at the expense of driving experienced and skilled people from their jobs, or the well-educated youth out of the country (*Pretoria News*, 2008). Addressing the country's skills shortages requires a combination of high-quality education, involvement of industry through proper job training, experience and hard work (Lubbe, 2008). Throughout the world there seems to be a shortage of skilled younger workers as older, experienced workers exit their jobs. This problem should be addressed by an adequate education system which transfers knowledge, but also by ensuring that graduates are work-ready and have skills that are useful to employers (Garrun, 2008). In the interim, industry may have to consider making the country more attractive to skilled immigrants, as it may take another decade to produce the much-needed skills (*Pretoria News*, 2008).

Although there is an undeniable national need at higher education institutions to enable the participation of previously disadvantaged students, the institutions have realized that they must also ensure that these participation strategies lead to successful outcomes (Wangenge-Ouma and Cloete, 2008). This realization is reflected in the government initiative to provide subsidies for access programmes in addition to the normal per-student subsidy, as long as the university produces adequate student throughput rates (MacGregor, 2009). The achievement of higher success rates may involve offering well-developed bridging programmes and vocationally-oriented centres to bridge the skills gap. Developing programmes that are accredited in industry will create a training sector within higher education institutions that can offer courses and ongoing training to produce individuals with skills and qualifications recognized by the commercial sector (Webster, 2008).

Knowledge of the factors that influence students' career-related decisions can enable potential employers and higher education institutions to understand students' choice of career path and, as a result, to influence students to follow a particular career path. Understanding students' career goals as well as the factors influencing career choice will give industry insight into how they can be successfully managed as employees. In this study, females placed more emphasis than males on 'overall job satisfaction', 'working with people', 'variety in work' and 'being well-qualified'. This distinction may assist employers in their selection and placement process. By identifying the career goals of potential employees, a firm is better able to assign employees to the correct positions within the organization as well as to develop them effectively for

opportunities', and 'information obtained from the media'. The following five factors did not show any differences: 'information and advice from parents and family', 'friends and acquaintances', 'work experience', 'role models', and 'family ties and commitments'.

Worth noting is the insignificant difference between male and female respondents with regard to the influence of role models on their career choices. Previous research indicates that the importance of role models differs significantly between males and females (Perrone *et al,* 2002; Counsell, 1996) and also that this 'people factor' has a significant influence on the career choices of students and other individuals (although it was only ranked ninth in this study). A possible reason for the insignificant difference between male and female students in this regard (and the low ranking) could be that students are uncertain about the influence role models might have on their career choices. In line with Counsell's (1996) research, this study found that male and female students did not differ in the level of importance they attached to information and advice from parents and close family members as an influence on their career-related decisions. This probably shows that, irrespective of gender, students attach the same weight to advice from family members.

Hypotheses 3 and 4

For Hypothesis 3, the differences between ethnic groups with regard to the perceived importance of their career goals were investigated. The results did not indicate an overall significant MANOVA result (p=0.277) and therefore no follow-up analyses were necessary. The results thus indicate that white and black students do not differ significantly from each other in terms of the importance they attach to career goals. One can conclude that, irrespective of ethnic orientation, career goals are relatively similar for young individuals, whether or not such goals are part of their career management process.

In the fourth hypothesis, possible differences between the two ethnic groups with regard to the perceived importance of influences on their career decision making were examined. The results are presented in Table 5. It can be seen that an overall significant result (p=0.000) was obtained. Consequently the null hypothesis is rejected and there is support for H_4. Univariate analyses revealed that white and black students differed with respect to nine of the thirteen listed career influences. For seven of the nine significantly different results, the black students showed higher importance levels (higher mean values). Thus black students consider 'courses and subjects studied', 'tutors', 'role models', 'job availability', 'personal future needs', 'considerations regarding affirmative action and employment equity opportunities' and 'information obtained from the media' as more important career influences than their white counterparts. The most significant influences for black students are affirmative action and employment equity opportunities (p=0.000). This can obviously be attributed to the current policy of redressing past inequities, following a racially segregated higher education system before 1994. Consequently, one of the five important policy goals of the National Plan for Higher Education is to achieve equity and diversity in the South African education system (Wangenge-Ouma and Cloete, 2008). On the other hand, white students considered 'information and advice from parents and close family friends' as well as 'friends and acquaintances' to be more important career decision making influences. It is clear that white students see family members and friends as influential sources in their career choices. There may be historical and socioeconomic reasons for this: whites have always had access to tertiary education, and therefore white parents are influencing factors for these young adults when they have to decide on a field of study and career. There is thus a history of educating oneself for a career.

Table 5. Mean values and MANOVA results for ethnic groups' perceptions of career influences.

Career influences	White	Black	Univariate analysis
Information and advice from parents and close family	4.00	3.81	**0.031**
Friends and acquaintances	3.54	3.22	**0.000**
Work experiences	4.06	4.05	0.878
Courses and subjects studied	4.03	4.32	**0.000**
Tutors	2.96	3.31	**0.002**
Role models	3.40	3.68	**0.009**
Family ties and commitments	3.57	3.64	0.507
Job availability	4.16	4.52	0.000
Personal future needs	4.55	4.69	**0.030**
Perceived skills and abilities	4.27	4.38	0.169
Limited education and/or learning opportunity	3.44	3.55	0.285
Considerations regarding affirmative action and employment equity opportunities	3.24	3.64	**0.003**
Information obtained from the media	3.26	3.49	**0.032**
Wilks' lambda:			
F-value	4.346		
p-value	**0.000**		

Managerial implications

The research results pertaining to career goals show that students consider the following goals as very important:

Table 1. Importance ranking of career goals.

Rank	Career goals	Mean	Very unimportant (%)	Unimportant (%)	Neutral (%)	Important (%)	Very important (%)
1	Being good at the job	4.77	0.4	0.2	1.4	18.1	79.8
2	Overall job satisfaction	4.69	1.2	0.4	1.8	22.7	74.2
3	Opportunities for promotion	4.57	0.4	1.4	6.4	24.2	67.6
4	Being well-qualified	4.53	0.6	2.3	6.8	24.4	65.9
5	Challenging work	4.19	0.8	1.6	11.7	49.4	36.5
6	Variety in work done	4.17	0.6	2.3	13.4	46.7	37.0
7	Wealth	4.09	0.8	1.4	13.3	53.3	30.3
8	A managerial position	3.97	3.7	3.1	20.7	47.0	27.9
9	Working with people	3.95	1.2	5.1	25.3	34.3	34.1
10	Managing your own business	3.78	2.7	8.4	28.3	29.4	31.2
11	Working abroad	3.47	1.2	7.8	43.5	27.3	17.7

country to work overseas (Hayward, 2008; Pike, 2008). Another goal that rated very low was 'managing your own business'. Given South Africa's high unemployment rate, this perception does not echo the frequently-expressed expert opinion that young people should become entrepreneurs and, when they cannot find jobs, they should create their own jobs (Evans and Swart, 2009).

Importance of career influences

Influences on career decisions are mainly those factors that have the power to impact on a student's career-related thinking. Table 2 reflects the way the respondents perceived the factors that could influence their careers – the results are presented in ranking order according to the overall mean values. It can be seen that respondents rated 'personal future needs', 'perceived skills and abilities', as well as 'job availability' as the three most important career influences. This is consistent with the South African government's priorities of creating job opportunities and developing skills to address the skills shortages (Mashalaba, 2007). South Africa's high unemployment rate could also have contributed to the high ranking of job availability and skills among the respondents. It is interesting that Counsell's (1996) research found that the perceived skills and abilities of students were the least important factor influencing their career choice. Also, information and advice from parents and close family were identified by South African students as only the sixth most important influence, whereas these were considered the most important by the UK students in Counsell's research. The lower ranking of parents' influence indicates some independence in career decision making, as students may feel that South Africa is a very different place now from what it was when

Table 2. Importance ranking of career influences on decision making.

Rank	Career influences	Mean	Very unimportant (%)	Unimportant (%)	Neutral (%)	Important (%)	Very important (%)
1	Personal future needs	4.59	0.2	0.2	3.3	33.2	63.1
2	Perceived skills and abilities	4.29	0.6	0.8	8.0	50.2	40.4
3	Job availability	4.23	1.8	3.5	11.1	36.7	46.9
4	Courses and subjects studied	4.10	0.4	2.5	16.6	47.4	33.1
5	Work experiences	4.05	1.2	4.1	16.8	44.1	33.8
6	Information and advice from parents and close family	3.94	0.6	3.1	21.9	50.0	24.4
7	Family ties and commitments	3.58	3.3	7.2	35.0	37.7	16.8
8	Friends and acquaintances	3.47	1.4	9.0	38.4	43.5	7.6
9	Role models	3.47	4.7	8.8	37.7	32.8	16.0
10	Limited education and/or learning opportunity	3.46	4.5	6.6	42.6	31.1	15.2
11	Considerations regarding affirmative action and employment equity opportunities	3.32	11.1	9.0	36.1	24.4	19.3
12	Information obtained from the media	3.31	5.7	10.5	40.0	34.3	9.4
13	Tutors	3.03	10.1	15.2	43.6	23.3	7.8

models who are seen as worthy of imitation. These two studies were conducted in the US and UK, respectively.

A key distinction in Counsell's (1999) and Counsell and Popova's (2000) research is that they identified the 'economic and political situation' as the most frequently mentioned influence on career-related decisions, whereas Counsell's 1996 study identified 'information and advice from parents and close family' as the most frequently mentioned influence. Previous research findings from other authors also suggest that people and situational factors play important roles in students' perceptions when a field of study and career choice are considered (Swanson and Tokar, 1991; Ackerman and Gross 2006). People factors are intrinsic and include advice from parents or relatives, influence by friends, school teachers and lecturers, and the influence of career role models. Situational factors, on the other hand, are extrinsic and include the economic situation, the job market, perceived needs, perceived skills and abilities and work experience.

The study discussed in this paper was designed to gain insight into South African students' perceptions regarding career choice. The process of transformation of higher education in South Africa puts pressure on higher education institutions to deliver the much-needed graduates for social and economic development, while simultaneously addressing equity and diversity. One way to achieve this is to gain a better understanding of the student market in terms of the career goals and factors that influence their career decision making.

Research objectives

The above literature review shows that various studies have investigated career goals and the importance of factors influencing students' career decision making (Swanson and Tokar, 1991; Counsell, 1999, Counsell and Popova, 2000; Orndorff, 2002; Sosik *et al*, 2004; Myburgh, 2005; Ackerman and Gross 2006; Hussain *et al*, 2007). Findings from several international studies have identified differences between gender groups in career goals and in influential factors in career decision making (Counsell, 1996; Le, 1999; Delmar and Davidsson, 2000; Van Praag, 2003; Piotrowski and Cox, 2004).

When the new government came to power in South Africa in 1994, a new code known as Black Economic Empowerment (BEE) was developed in an attempt to rectify the imbalances of the past. The aim of BEE was to empower the majority of the people by offering them jobs and the necessary skills to compete in the business world. However, the issues surrounding BEE may influence the perceptions of white and black students with regard to their career prospects in South Africa. This possibility led to a decision to investigate ethnic differences in the study in addition to gender differences. The inclusion of ethnic differences is in line with several international studies which have also investigated cultural differences between groups in relation to career decisions (Greene and Storey, 2004; Williams, 2004; Myburgh, 2005; Agarwala, 2008; Ng *et al*, 2008). Another motivating factor for investigating ethnic differences is that it has been recognized that a career decision is a blend of individual choices marked by both social and cultural factors (Greene and Saridakis, 2008).

Much research has been conducted in First World countries on students' career perceptions and goals. However, very little has been conducted in Third World countries, including South Africa. In formulating the research hypotheses, due regard was paid to South Africa's richness in cultural groupings, with, as already noted, no fewer than eleven official languages. Accordingly, the following hypotheses were formulated for the study and for application in a South African environment:

- H_1: There is a significant difference between male and female students with regard to the perceived importance of their career goals.
- H_2: There is a significant difference between male and female students with regard to the perceived importance of influences on their career decision making.
- H_3: There is a significant difference between white and black students with regard to the perceived importance of their career goals.
- H_4: There is a significant difference between white and black students with regard to the perceived importance of influences on career decision making.

Methodology

Sampling and data collection

The target population for the study consisted of undergraduate Bachelor of Commerce (BCom) students in the Faculty of Economic and Management Sciences on the main campus of the University of Pretoria in South Africa – one of the largest residential universities in South Africa, with 38,000 contact students and over 1,800 academic programmes. The Faculty of Economic and Management Sciences is the largest faculty at the University of Pretoria and has some 9,000 registered contact students (University of Pretoria, 2008). A non-probability, convenience sample was drawn by distributing questionnaires at lecture venues.

A self-completion questionnaire was used because this is a fast, cost-effective, resourceful and precise means of accessing information about a population. The necessary permission was obtained from the Ethics

accounting, engineering, IT and medicine) which has to be overcome in the next five to ten years (Koorts, 2009). Unfortunately, it appears that the skills in short supply in South Africa are the same as those for which Australian and Canadian companies are head hunting in South Africa (*Financial Mail*, 2008). The movement of skills can, among other things, be attributed to demand in an increasingly globalized labour market (*Financial Mail*, 2008). This might, however, change with the current worldwide economic problems.

Labour experts estimate that at least 400,000 pupils who complete their secondary education join the unemployed in South Africa every year (Naidu, 2008). On the upside, over 700,000 students are enrolled at tertiary education institutions in an attempt to fulfil their dream of one day joining the world of work (Department of Education, 2008). Linked to the skills shortages experienced in South Africa are students' perceptions of their own career paths. Such perceptions indicate whether students consider it important to set career goals and a strategic plan at an early stage, and what factors they perceive as crucial with regard to career goals and choices (Myburgh, 2005). Educators and industry have a responsibility to equip students with the necessary career guidance and awareness to ensure that they have the skills they will need to adapt to the job environment when they leave education. Several research studies have concluded that there is a need for a better understanding of the career-related thinking and actions of individuals already pursuing a career, as well as of undergraduate students who are preparing for their careers (Swanson and Tokar, 1991; Counsell, 1996; Piotrowski and Cox, 2004; Myburgh, 2005).

The aim of this study is to determine which factors are important for students at higher education institutions in formulating career goals and what influences their career choices, with particular reference to differences in gender and ethnic orientation. This is especially relevant in South Africa, often referred to as the 'rainbow' nation because of its diverse cultures and eleven official languages. Furthermore, South Africa's historical and cultural background may shape students' perceptions of their career prospects. The results of this study could provide a better understanding of the career-related thinking and actions of current undergraduate students.

The paper begins by examining career goals and career decisions as related concepts. This is followed by a description of the research aim and methodology, after which the results are presented and discussed. Finally, the paper discusses the managerial implications of the study and concludes by outlining its limitations and making recommendations for future researchers.

Literature background

South Africa seems to be one of the big losers in the global race for skills. Its best technicians, doctors and engineers are recruited by companies all over the world (*Financial Mail*, 2008). Some believe that the best way to close the skills gap is through improved education, to equip students to fill the gaps once they have graduated (Hartley, 2008). This raises the question of how those who are being educated manage their career goals with the aim of contributing to the South African economy in addressing the skills shortage. The literature review that follows provides some background on the role of career goals and career decisions in students' career management processes.

Career goals

Career development theory states that individuals can make a decision only once they know what careers are available to them and have realistic ideas on how to get there (Stead, 2008). This process is made up of incremental stages of progression. First, there is the awareness stage, which starts at about seven years of age and goes through to about 14. The career exploration stage starts around the age of 14 and extends into tertiary studies and even into the first or second job. Globalization, increased competitiveness, growing populations and a larger number of students in tertiary education have increased the importance of setting appropriate career goals (Star, 2008). It is advisable for students to set goals for their career advancement, as this is instrumental in guiding their actions towards the fulfilment of future career-associated needs. A career goal has been described as a future position which an individual aspires to as part of his or her career and serves as a point of reference in the direction of one's career (Duxbury *et al*, 1999). The different needs of individuals are reflected in their attainment of different career goals (Counsell, 1996). A career goal can also clarify thinking, motivate and direct behaviour, and serve as a basis for the development of a career strategy (Greenhaus *et al*, 1995).

Prior research suggests that individuals with specific and challenging career goals perform more successfully and productively than those without such goals (Greenhaus, 1987, in Counsell, 1996; Ribchester and Mitchell, 2004). Findings from a US study determined that more than 80% of the 220,000 incoming college freshmen rated 'finding a better job' as a very important reason for attending college, while only four per cent planned to seek career guidance and advice to help them make more informed decisions (Orndorff, 2002). According to Ribchester and Mitchell (2004), students can be categorized into three groups: those with a clear

National Science Board (2002), *Science and Engineering Indicators 2002*, National Science Foundation, Arlington, VA.
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NSF (2007), *US R&D Increased 6.0% in 2006 According to NSF Projections*, NSF 07–317, Division of Science Resources Statistics, National Science Foundation, Arlington, VA.
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Schon, D.A. (1963), 'Champions for radical new inventions', *Harvard Business Review*, Vol 41, pp 77–86.
Scott, S.G., and Bruce, R.A. (1998), 'Following the leader in R&D: the joint effect of subordinate problem-solving style and leader–member relations on innovative behavior', *IEEE Transactions on Engineering Management*, Vol 45, pp 3–10.
Shim, D., and Lee, M. (2001), 'Upward influence styles of R&D project leaders', *IEEE Transactions on Engineering Management*, Vol 48, pp 394–413.
Simonton, D.K. (1984), 'Genius, creativity, and leadership: historiometric inquiries', Harvard University Press, Cambridge, MA.
Tornatzky, L., Lovelace, K., Gray, D.O., Walters, S.G., and Geisler, E. (1998), 'Center leadership: putting it all together' in Gray, D.O., and Walters, S.G., eds, *Managing the Industry/University Cooperative Research Center: A Guide for Directors and Other Stakeholders*, Battelle Press, Columbus, OH.
Tornow, W.W., and Pinto, P.R. (1976), 'The development of a managerial job taxonomy: a system for describing, classifying, and evaluating executive positions', *Journal of Applied Psychology*, Vol 61, pp 410–418.
Tushman, M.L., and Anderson, P. (1986), 'Technological discontinuities and organizational environments', *Administrative Science Quarterly*, Vol 31, pp 439–465.
West, M.A., Borrill, C.S., Dawson, J.F., and Brodbeck, F. (2003), 'Leadership clarity and team innovation in health care', *Leadership Quarterly*, Vol 14, pp 393–410.

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Appendix A

Director interview protocol

Background

1. How would you describe your centre's mission? Additionally, if your centre has a formal mission statement, what is it?
2. How is your centre structured? For example, what roles exist and how do they interact with or report to each other? What are the processes by which the centre's work gets done?
3. What is your primary area of expertise? What previous experiences have proven relevant to your role as director?

Centre performance

4. How is your centre's performance measured or how is it held accountable?
5. What factors would you say have the most influence on the centre's performance?

Director performance

6. What is your role as director – what is expected of you?
7. How is your performance as director measured? How are you held accountable?
8. What factors are most important to your success as director? For example, what do you find most challenging or difficult, most helpful?
9. What do you like the most about your job as director?
10. What would you say are your primary strengths as director?
11. What would you say are your primary weaknesses or limitations as director?
12. How would you say your leadership has changed during your time as director, if at all?
13. What motivates the other individuals involved in the centre? What role do you play in their motivation?
14. How would you characterize your relationships with other colleagues in the centre?
15. How much longer do you see yourself being in this role? What is the most likely reason you will exit your role as director?

Critical incidents

16. Please describe a notable success story that occurred with your centre.
17. Please describe a notable centre failure, crisis, or difficulty.

Numeric ratings

18. On a scale from 1 to 10, where 5 is adequate and 10 is outstanding, how would you rate the centre's performance? What would have to change for the centre to get a higher rating?
19. On the same scale, how would you rate your performance as centre director? What would you have to do to get a higher rating?
20. Is there any other information you think might help others to better understand the role of centre director?

non-R&D settings is instructive. As expected, the role of centre director has some components in common with leadership in other settings. Specifically, *broad thinking*, *balancing competing stakeholders*, *obtaining resources*, *interpersonal skill/abrasiveness*, *team building*, *disorganization* and *conflict avoidance* all have direct precedents in previous research. However, the high importance attached to *obtaining resources* in our study (it was the single most frequently mentioned competence) is somewhat surprising. Further, *ambition/work ethic* and *technical expertise*, although not explicitly represented in previous taxonomies, have logically obvious facilitative value for other dimensions that have been explicitly identified. One possible difference in R&D settings is that *technical expertise* here refers to expertise in the tasks of individual contributors (researchers), whereas previous taxonomies have tended to emphasize expertise in managerial tasks. Dimensions similar to *embracing ambiguity* and *leveraging social capital* have been identified in previous research on entrepreneurship (for example, Hmieleski and Ensley, 2007), which was mentioned by Tornatzky *et al* (1998) in the context of leading a UCRC. Finally, the importance of *granting autonomy* has been well documented in previous research on leadership in R&D settings other than UCRCs (for example, Amabile *et al*, 2004; Farris, 1988).

However, the dimensions of *navigating bureaucracy* and *task adaptability*, as defined here, would seem to be potentially specific to the role of UCRC director. All large organizations contain some degree of bureaucracy of course, but UCRC leaders are frequently charged with navigating *unfamiliar* bureaucracies, such as those in external partner organizations. Managers in more traditional settings might be expected to gain some familiarity with their own organization's bureaucracy over time. But UCRC leaders face a diverse and frequently changing array of bureaucracies that must be learned and re-learned.

Task adaptability, defined here as the ability to alternate readily between leadership tasks and individual contributor tasks, might be expected of first-line managers in very small organizations (such as restaurants and retail stores), where managers must occasionally work alongside individual contributors to compensate for insufficient staffing. But for *task adaptability* to emerge as an important factor in the success of executive leaders, such as UCRC directors, is unexpected. Except in the specialized circumstances just mentioned, a general trend is for individual technical expertise to become less important as managers rise in organizational hierarchies (see, for example, Charan *et al*, 2000). In this regard, the ongoing importance of both *task adaptability* and *technical expertise*, as defined here, would also appear to contribute to the distinctiveness of the UCRC director's role.

In summary, our research suggests that UCRC leadership may represent a somewhat distinct hybrid model of leadership. Based on our data, these leaders appear to have qualities in common with leaders in non-R&D settings, like *broad thinking*, although the importance attached to *obtaining resources* for UCRC leaders was somewhat surprising. In addition, these leaders appear to exhibit qualities that are typically associated with R&D leaders, including *technical expertise*. Finally, these individuals also appear to exhibit some qualities that are associated with leaders in very different roles (such as entrepreneurial roles) and qualities, like *task adaptability*, that may be unique to the UCRC role.

Future directions

Perhaps not unexpectedly, given the dearth of empirical research that has specifically addressed UCRC leadership, there is no systematic knowledge base for guiding the selection and development of UCRC leaders. We believe the dimensions identified here can provide a basis for further developments in both of those domains. Further efforts by the current authors are already underway to validate the dimensions identified here empirically and to develop a standardized multi-rater ('360 degree') leadership performance assessment instrument. Multi-rater assessment instruments capture potentially discrepant perceptions of leadership performance from the perspectives of multiple observer groups, such as superiors, peers, subordinates and external stakeholders. When completed, this tool will provide a common metric, allowing UCRC leaders' performance to be compared meaningfully across centres. The greater efficiency afforded by a quantitative measure will also allow for the larger sample sizes needed to explore differences in perceptions across data sources (for example, directors versus observers), industry sectors and geographical regions. Further, by linking standardized measures of UCRC leader performance to centre outcomes, future research can identify the relative importance of specific leader competencies to centre-level criteria, thus advancing towards the goal of being able to predict potential leaders' future performance for succession planning and also to assist current UCRC leaders in enhancing their own effectiveness through personal development.

Conclusion

In sum, we believe this research has brought a much-needed empirical approach to the under-studied area

coded into this category if they included a reference to the director working long hours, making personal sacrifices or displaying a competitive/achievement-oriented demeanour. A sample response from this category was:

> 'There was a time when I would routinely work 70 to 80 hours a week. I'm probably down to 60, and I don't know whether that's good or bad. That's just the way I am. My computer comes home with me. I check e-mail at 10:00 at night.'

The need for directors to *balance competing stakeholders* was mentioned by 55% of respondents. Responses were coded into this category if they included references to the director's obligation to take into account the needs of more than one constituency, either within or across centre boundaries. A sample response was:

> '[I have to] make sure that we get around and meet our commitments to each of our sponsoring companies.'

The importance of *granting autonomy* to individuals working in the centre was mentioned by 50% of respondents. Responses were coded into this category if they included a reference to directors giving researchers latitude to conduct their work as they chose. A sample response was:

> '[My director] has a clear vision of what he wants; he communicates it clearly and then lets people do their job. He doesn't interfere.'

The ability of directors to *navigate bureaucracy* successfully was mentioned as important by 45% of respondents. Responses were coded into this category if they referred to the need for directors to understand bureaucratic procedures, including budgets. A sample response was:

> 'I have to present a budget to the board every year and at the biannual meetings a report demonstrating how we're running that budget. The budget's comprehensive in terms of all expenses and income, including those more specific research projects and I guess in terms of the major objective to maintain the fiscal credibility or viability of the institute.'

Forty-two per cent of respondents mentioned directors' *interpersonal skill* as a strength. This category was defined broadly and included any comment that referenced directors' ability to interact effectively with other people, such as through their tact, listening skill, communication skill, patience, etc. A sample response was:

> 'He was a nice – I wouldn't say easy-going, but gentle – pusher, shover, as opposed to a tyrant who was trying to be a dictator and forced everything the way he wanted it to go, so it worked really well with the members.'

Logically related to interpersonal skill was the directors' ability to *build and maintain a team*, which was mentioned by 37% of respondents. Responses were coded into this category if they mentioned demands on directors to recruit centre faculty or staff, retain them over time or facilitate their functioning as a team. A sample comment was:

> 'To try and find a way to get this incredibly diverse faculty to interact with each other is really one of the central jobs of the director. Once you get your faculty talking, things can sort of take care of themselves as long as you point them in the right direction.'

Broad thinking was mentioned by 38% of respondents, and was defined as the ability or inclination to think in terms of the centre's work in relation to the larger society. Responses were coded into this category if they included references to the director's monitoring of the external environment, understanding of the implications of the centre's work for industry or society or for past or future research. A sample response from this category was:

> '[A strength is] being active nationally in different meetings so I can see national trends and being able to bring back those trends and point folks into the more relevant areas.'

Embracing ambiguity was mentioned by 27% of respondents. This category included references to the role of the centre director as lacking a formal definition or to the demand on the director to define his or her own role. A sample comment was:

> 'There's not a lot of formality, in terms of ''here are the written goals or objectives for my position''.'

Responses were coded as indicating a need for directors to *leverage social capital* if they mentioned a benefit of the director's personal or professional contacts for the centre's work. Twenty-one per cent of respondents made comments in this category. A sample response was:

industry-based laboratories. Further, universities have established infrastructures to support research. For example, universities conducted approximately 43% of all basic research in the USA in 2000 (NSF, 2002).

However, there are struggles unique to UCRCs that must be managed. Cyert and Goodman (1997) identified three of these dilemmas. The first is that university and industry partners have different cultures. Universities create and disseminate knowledge, while companies produce products and services in a highly competitive environment. Companies' time is oriented towards quarterly goals, while universities' timeframes are longer-term and less well defined. Scheduling and adhering to deadlines for research projects can be difficult. The cultures of universities and industry also differ with regard to terminology. University researchers are more familiar with terms such as 'hypothesis', 'model', and 'statistical significance', whereas people from industry tend to speak the language of business. The second dilemma is that the products produced by the two types of organization differ. Most industry partners produce concrete products, services or procedures. University members work toward creating contributions to knowledge in the form of new theories, concepts, models and findings. The third difference between industry and university partners is their susceptibility to exogenous shocks. Industry is more prone to shocks such as mergers, downsizing and fluctuations in the economy. Universities are generally more stable; shocks are more minor in scope and may include losing key faculty members to other institutions and administrative turnover.

Leadership in UCRCs

Although one might assume that much of the research on R&D leadership could be applied to UCRC leadership, UCRCs appear to face distinct challenges that require unique characteristics and behaviour in their leaders. Unfortunately, empirical literature (quantitative or qualitative) on leadership in this setting is almost non-existent. In a rare exception to this trend, Tornatzky *et al* (1998) proposed several roles that UCRC leaders had to navigate to a greater extent than traditional R&D leaders. UCRC leaders are required to act entrepreneurially, as they found and develop an organization from the ground up. They must cultivate a core of distinguished academics and simultaneously obtain industry support. However, a UCRC leader faces different challenges from those of a commercial entrepreneur. UCRC directors navigate a more constrained environment with few alternatives and more limitations since they work within the confines of government regulations and university bureaucracy, as well as industry rules and policy.

Another major challenge that UCRC leaders face to a greater degree than R&D leaders is difficult boundary-spanning. Not only is the boundary spanning more difficult than in traditional organizations, but it is also different in nature. Rather than simply navigating multiple stakeholders, UCRC leaders must traverse the competing priorities of university-based researchers and the industry constituents. Whereas researchers usually have autonomy over their own research agendas and freely disseminating knowledge, industry partners value gaining a competitive advantage by controlling research topics and the dissemination of results (Tornatzky *et al*, 1998). An additional challenge UCRC directors increasingly face is boundary-spanning between universities and university administrations in multi-campus centres. For instance, most National Science Foundation UCRCs are required to maintain participation by more than one university. In these situations directors must recruit faculty and create partnerships not only within their own university but also in other universities where they may have less authority and less knowledge of the internal politics. Not surprisingly, given the challenges involved in this task, recent research has found that multi-institutional university research collaborations exhibit lower productivity than single-site initiatives (Cummings and Kiesler, 2007).

In sum, effective leadership is important to the performance of R&D organizations, but virtually no empirical research has specifically addressed the unique demands of the UCRC leader's role. Previous research on leadership in R&D settings may well be applicable to the R&D component of UCRCs, but UCRC leadership roles include other components as well, potentially requiring a unique combination of characteristics in leaders if they are to be successful. The current study represents an initial step towards filling this gap in the research literature by empirically mapping the dimensionality of UCRC leader performance. Specifically, the goal of the current research was to identify critical components of the UCRC leadership role to serve as the basis for a future UCRC leadership performance measure.

Method

Participants

An Internet search for Websites of US UCRCs identified 58 in which the centre director's contact information was posted. Invitations to participate in the study were e-mailed to all of these directors, twelve of whom initially indicated willingness to participate. Four subsequently failed to participate due to scheduling problems or stopped responding to contacts by the researchers, leaving eight directors as focal participants.

furthering industry's goals (Gray, 1998). In these research centres, industry partners typically provide resources – often in conjunction with government or foundation sponsorship – for research programmes that are primarily administered and executed by academic investigators at one or more institutions.

Although UCRCs have existed for quite some time, they have experienced spectacular growth over the past decade or two and are now considered an important component of national and subnational innovation systems. For instance, more than a decade ago Cohen and his colleagues identified over 1,100 UCRCs in the USA (Cohen *et al*, 1994). While these estimates have not been updated recently, it seems certain that an even larger number of the 14,000 university-based and non-profit research centres in the USA and Canada and the over 27,500 worldwide would meet the definition of a UCRC (*Research Centers and Services Directory*, 2006). More importantly, the value of UCRCs has become so obvious that Feller (1997) concludes that they have become the dominant mechanism for promoting university-based technology transfer.

Because of the interorganizational, cooperative nature of UCRCs, their leaders must perform multiple roles, including those of entrepreneur, boundary-spanner, scientist, administrator, champion and gatekeeper. Effective leadership has been identified as a critical factor in the success or failure of a centre (Tornatzky *et al*, 1998). But, despite a large literature addressing leadership in other settings, published research on UCRC leadership is almost non-existent. Some of the research that has addressed leadership in other R&D settings may also be relevant to UCRCs. Although there are important structural differences between UCRCs and most other research organizations that limit the generalizability of previous research to this unique setting, we briefly summarize below the R&D leadership literature before describing an empirical investigation of the dimensionality of leadership performance in UCRC settings.

The R&D leadership literature

Research and development activity

R&D has been defined as 'expenditures devoted to the discovery and application of new scientific and engineering knowledge' (Jankowski, 2001, p 323). Typically, R&D activities are conducted by specialized teams or centres as auxiliary functions of businesses, universities or government agencies. R&D encompasses a wide range of activities, from basic and applied research to the development of useful materials, machines, systems or methods. It is generally acknowledged that investment in R&D stimulates the economy, is imperative for national defence and scientific discovery, and contributes to the overall welfare of society. Moreover, R&D has been found to be one of the most important success factors for innovation in organizations (Jankowski, 2001).

Research and development has become a large societal enterprise, with US organizations spending an estimated $58.4 billion on basic research, $66.4 billion on applied research and $187.3 billion on development in 2004 (NSF, 2006a). American expenditures on R&D grew to $342.9 billion in 2006 (NSF, 2007).

R&D output is often measured in terms of publications and patents, as these provide indicators of escalation from basic research to practical application and describe the content and priorities of industry-related scientific endeavour. Indeed, article publication is crucial for individual career advancement in most scientific fields. Data available on the authorship of articles also provide information regarding collaboration between institutional, disciplinary and national boundaries. Increasing industry–university collaboration is a clear indicator of the relevance of academic research to commercial activity. In 2003, 12,114 academic articles with an industry co-author were published – six per cent of all academic articles published that year and 25% of the 48,242 articles with a non-academic co-author (NSF, 2006b). More than 3,200 US patents were applied for by academic institutions in 2003 (NSF, 2006a).

Researchers have also found evidence of the importance of R&D to organizational outcomes. Cohen and Levinthal (1990) found that an organization's ability to exploit new technologies depended on the presence of in-house research and development divisions. Tushman and Anderson (1986) found that organizations with R&D divisions grew more rapidly than those without and were more likely to survive unexpected changes. There has even been some evidence to suggest that profit and growth may be related to creativity and innovation generated by R&D teams (Nystrom, 1990).

Leadership in research and development

While the amount of research conducted on R&D leadership has been small relative to research on other leadership settings, the number of studies investigating leadership in R&D organizations is growing. Farris (1988) identified three categories of R&D leadership research: research investigating the impact of the leader on the organizational climate, research on the roles performed by leaders in R&D organizations and studies of leadership theories. Using a modified version of Farris's taxonomy, we summarize the more recent research in Table 1. A more comprehensive review of

Pressman, L., Guterman, S., Abrams, I., Geist, D., and Nelsen, L. (1995), 'Pre-production investment and jobs induced by MIT exclusive patent licenses: a preliminary model to measure the economic impact of university licensing', *Journal of the Association of University Technology Managers*, Vol VII, pp 49–82.

Sampat, B. (2002), 'Private parts: patents and academic research in the twentieth century', paper prepared for Research Symposium of the Next Generation of Leaders in Science and Technology Policy, Washington, DC, 22–23 November.

Sampat, B.N., Mowery, D.C., and Ziedonis, A.A. (2003), 'Changes in university patent quality after the Bayh–Dole Act: a re-examination', *International Journal of Industrial Organization*, Vol 21, pp 1371–1390.

So, A.D., Sampat, B.N., Rai, A.K., Cook-Deegan, R., Reichman, J.H., *et al* (2008), 'Is Bayh–Dole good for developing countries? Lessons from the US experience', *PLoS Biology*, Vol 6, No 10.

Stevens, A.J. (1994), 'Measuring economic impact', presentation at AUTM Advanced Licensing Course, Phoenix, AZ, December.

contributions to the benefit of the USA and its citizens were recognized by a resolution of the US House of Representatives on 6 December 2006:

> 'The Bayh–Dole Act (Public Law 96–517) has made substantial contributions to the advancement of scientific and technological knowledge, fostered dramatic improvements in public health and safety, strengthened the higher education system in the United States, served as a catalyst for the development of new domestic industries that have created tens of thousands of new jobs for American citizens, strengthened States and local communities across the country, and benefited the economic and trade policies of the United States.'

Moreover, an important factor that is often overlooked is that the success of the Bayh–Dole Act in motivating technology transfer has been accomplished without cost to the taxpayer. In other words, no separate appropriation of government (read taxpayers') funds was needed to establish or manage the effort. Yet its contributions to the US economy and to its citizens, as well as to the citizens of the world, has been exemplary. For example, in FY 1999 US economic impact models showed that $40.9 billion could be attributed to academic licensing, and that 270,900 jobs were created.[8]

Why was the Bayh–Dole Act a determinatiing factor in the evolution of university technology transfer? There are a number of reasons that critics conveniently overlook:

(1) It produced order out of chaos because it established a uniform government patent policy. Prior to Bayh–Dole, when federal monies were used in whole or in part in the making of an invention, there were some 20 agency policies depending on where the research was funded. Indeed, frequently an agency covering different programmes had more than one patent policy. Because universities received federal funds from a wide range of sources, this made it extremely difficult, if not impossible, to sort out the applicable policies and restrictions on patenting and licensing by the university. The most restrictive of the policies generally controlled, but all applicable funding agency policies had to be considered, as did the bureaucratic climate and restrictions within a given agency. Consequently, with the exception of the IPA programme, a federally-supported university invention seldom found its way to the marketplace.
(2) Bayh–Dole was the first statutory authority for government agencies to obtain, hold and license patents generated within government laboratories. This greatly increased the effective management of important inventions made by federal employees, previously languishing without development.
(3) It was the template for the subsequently passed Federal Technology Transfer Act, which promoted technology transfer from federal laboratories and recognized the contributions of federally-employed inventors. Indeed, the first version of this legislation by Senator Dole was written as an amendment to Bayh–Dole.
(4) It called for the sharing of royalties collected by the contractor with inventors, thus recognizing their imaginative scientific contributions and supplying them with the incentive to consider the practical applications of the results of their research. It also promoted contractors' use of the expertise of inventors in the technology transfer function.
(5) It promoted collaboration among scientists with diverse funding from different federal sources to explore and embrace interdisciplinary approaches to solving scientific challenges.
(6) It promoted the science–innovation interface through the establishment of a new university–industry relationship because of the certainty of title to inventions retained by universities under the provisions of the Act. This was, and still is, the critical element in private-sector development of inventions for the marketplace.
(7) It promoted private-sector as well as government investment in university research.
(8) It promoted innovation and the attendant creation of jobs through, in part, its mandate to give preference to US industry and small business in technology transfer practices.
(9) It protected confidential information in the possession of the contractor and its licences from undue and untimely disclosure – a prime consideration for the private sector in a globally competitive economy.
(10) It preserves certain rights in the government to protect the public against non-use or unreasonable use of inventions supported in whole or in part with taxpayers' money.
(11) It provides universities and non-profit sectors with the possibility of generating income to support research and educational activities through the technology transfer function.

The suggestion that the Bayh–Dole Act has not been a critical factor in the development of university technology transfer, and that this evolution would have occurred anyway, seems to us simply unsupportable.

intellectual property protection provision in Article I, Section 8 of the Constitution. Their faith in creating such incentives through a strong and viable patent system was well placed. As President Abraham Lincoln aptly stated, without a patent system 'any man might instantly use what another had invented; so that the inventor had no special advantage from his own invention. The patent system changed this; secured to the inventor, for a limited time, the exclusive use of his invention and thereby added the fuel of interest to the fire of genius, in the discovery and production of new and useful things.' Strangely, the modern critics think that the way to innovation is to turn Lincoln's dictum on its head.

Inventor Frederick Cottrell, when founding Research Corporation, noted that '[. . .] a number of meritorious patents given to the public absolutely free have never come upon the market chiefly because what is everybody's business is nobody's business'. It was precisely because inventors could secure protection for their discoveries and inventions that the 20th century became an era of huge innovation in the USA. It can hardly be disputed that, because of such protection, the benefits to humanity have been enormous. While the critics bemoan the ability of the patent system to grant such ownership of intellectual property, the only alternatives are open-source technology or trade secrets, neither of which provides similar motivation and incentives for innovation. It is truly the protection that the patent system creates that makes the commercial development of groundbreaking discoveries possible.

Developing countries would do well to consider these hard-won lessons when urged by external 'experts' to give away the results of their research. Interestingly, South Africa recently enacted a Bayh–Dole type law to help integrate its research universities fully into its economy. That a country which has changed so dramatically in recent years can look past the speculative fears of the critics and lay the groundwork for a confident future should give hope to us all.

Critics have also raised concerns that Bayh–Dole harms the advancement of science. Contrary to the anecdotes that are offered as the basis for that allegation, the data show that the law has substantially contributed to the US economy, and that US science is actually better because of university–industry research collaborations. Additionally, university researchers are successfully balancing patenting and publishing, and not shifting their focus away from fundamental research. In 2005, according to the President's Council of Advisors on Science and Technology (PCAST, 2008, p 22), fully 29% of articles authored worldwide by scientists and engineers were from the USA:

> 'Publication and citation of scientific results in peer-reviewed journals is one common metric for evaluating research outputs [. . .] The United States remains the world leader in citations of S&E [science and engineering] research articles. The number of US articles with co-authors by sector is a metric that can be used as an indicator of public–private research partnerships. Between 1995 and 2005, co-authorship with academic institutions increased by 10.3 percent, the largest percentage point increase of all cross-sector co-authorships.'

This co-mingling of the best and brightest minds in the public and private sectors in authoring joint scientific publications was fostered by the Bayh–Dole Act. Before the Act was passed, industry segregated its most creative researchers from university collaborations because the federal government could assert ownership rights in resulting inventions when federal support of university research was also present.

The health of US scientific publications is also reflected in the findings of the National Science Board's 2008 *Science and Engineering Indicators* report (NSB, 2008, Vol 1, p 5–7). Traditionally, about three-quarters of all US scientific and engineering publications come from academia. In its 2008 report, the NSB found:

> 'Although the US share of world article output and article citations has declined, the influence of US research articles has increased, as indicated by the percentage of US articles that are among the most highly cited world-wide. In 1995, authors from US institutions had 73% more articles in the top 1% of cited articles in all S&E fields than would be expected based on US total article output; in 2005, the percentage had grown to 83%.'

That the share of US scientific papers has fallen is because of the huge explosion of international publications, particularly from Asia. However, while the percentage of US publications has decreased, their scientific impact has increased. Scientific papers by US researchers are the most cited across every field of science (NSB, 2008, Vol 1, p 5–41). The number of citations by other authors is the standard criteria for determining the significance of a scientific publication in its field. The report explains (NSB, Vol 1, 2008, pp 5–49–5–50):

> 'In other words, a country whose research has high influence would have higher shares of its articles in higher citation percentiles.
>
> This is the case in every field for US articles – only US publications display the ideal relationship of

licensing rates for the 28,000 patents owned by the US government before BD to imply that the pre-BD legal regime was not conductive to commercialization. But as Eisenberg has argued, that figure is misleading because the sample largely comprised patents (funded by the Department of Defense) to which firms had already declined the option of acquiring exclusive title. Moreover, these figures are of questionable relevance to debates about public sector research institutions, because most of the patents in question were based on government-funded research conducted by firms, not universities or government labs.'

In our view, this assertion is wrong on both counts. In her referenced paper, Eisenberg (1996) maintains that 'the primary argument against government ownership was a statistical one' based on the 'testimony of numerous witnesses' that 'only a small percentage of its estimated 28,000–30,000 patents had been successfully licensed and exploited commercially'. She further submits that '. . .the statistical evidence presented was inadequate to document this claim' because it 'reflected a huge selection bias; as it consisted largely of inventions made by contractors whose research was sponsored by DOD . . . that could have retained title to the patents if they had wanted to do so'.

On the basis of her analysis, Eisenberg (1996) concludes that,

> 'It is hardly surprising that few firms were interested in taking licenses from the Government to patents that had already been rejected by contractors that could have been owned by them outright if they had found them at all commercially interesting.'

Eisenberg alleged that 17,632 of the 28,021 inventions in the government patent portfolio were made by Department of Defense (DOD) contractors, waived to the government because they lacked commercial importance. However, a review of the actual data indicates that this in fact was not the case. The evidence that fewer than 5% of government-owned inventions were being successfully licensed came from the 1976 Federal Council for Science and Technology (FCST) combined report (see Figure 3).[7] But in her paper, Eisenberg (1996) fails to note that the 1976 report clearly established that the 17,632 DOD patents included:

(1) 7,046 US patents granted during the 1970–76 reporting period to DOD employees obligated to assign their rights to DOD.

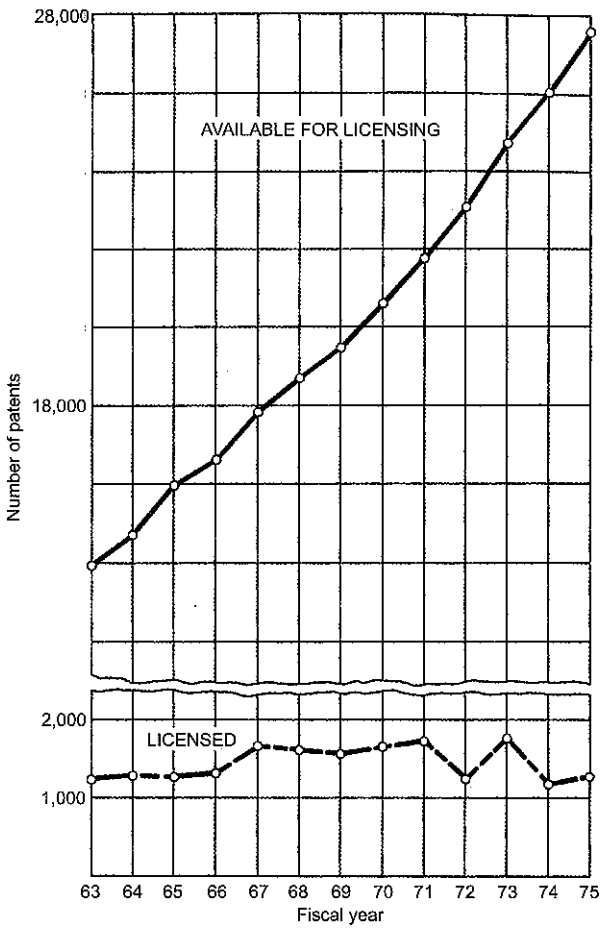

Figure 3. Licensing of government-owned interventions, 1963–75.

Source: Federal Council for Science and Technology Report on Government Patent Policy, Combined Dec. 31, 1973 through Dec. 31, 1976.

(2) 2,594 US patents based on reported inventions during the 1970–76 reporting period from contractors.
(3) In addition, a portion of these 2,594 contractor-generated inventions were taken from universities and other non-profits which, because of the DOD title policy then in place (prior to the passage of the Bayh–Dole Act), had no choice but to assign their inventions to the government.

Combining the two categories in (1) and (2) above gives a total of 9,640 patents accrued to the DOD patent portfolio during the 1970–76 reporting period, or about one-half of the 17,632 DOD patents identified in the report.

The remaining 7,992 patents (17,632 – 9,640) are unexpired patents granted and assigned to DOD prior to 1970 that remained open for licensing within the 1970–76 reporting period. Since there are no data in the

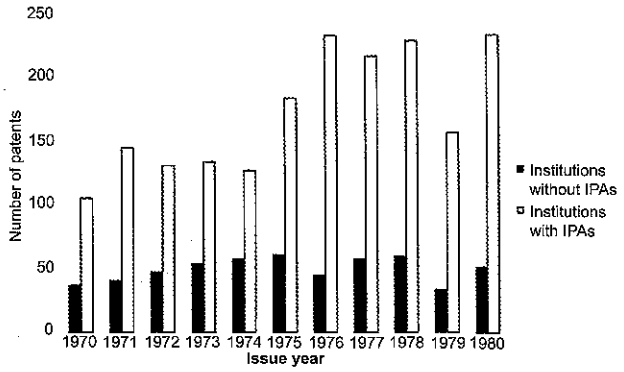

Figure 1. Mowery and Sampat's (2001) Figure 9 – 'Patenting by Carnegie research universities, by IPA status'.

> factors appear to have influenced growth in university patenting in the 1970s. Interestingly, only one of these factors (the IPAs) represented a change in federal policy toward the patenting of publicly funded research. It is likely that a similar diverse range of factors, and not the Bayh–Dole Act alone, underpinned the continued growth of US university patenting after 1980.' (Mowery and Sampat, 2001.)

What is striking about this conclusion is that Mowery and Sampat's Figure 9 (see Figure 1) clearly illustrates the impact of IPAs on university patenting. The chart shows that while the IPA programme was the only one of the factors cited as 'a change in federal policy toward patenting publicly funded research', it clearly made a dramatic and sustained impact that was not occurring without it.

Even their Figure 10 (see Figure 2) underscores the importance of the IPA programme on university patenting. IPA participants double the number of reported patents between 1973 and 1975. The increase of reported inventions by IPA participants increases by almost 400% between 1974 and 1976 according to the

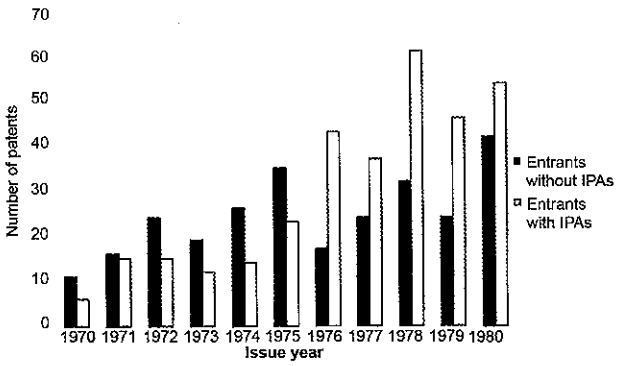

Figure 2. Mowery and Sampat's (2001) Figure 10 – 'Patenting by Carnegie research universities, by IPA status – entrants only'.

figure. Even more striking, as the IPA programme starts to grow at the NSF, and participants increase at NIH, as shown in Tables 1 and 2, IPA schools permanently pass those not in the programme in 1976 – and never look back.

The impact of Bayh–Dole on individual universities like MIT which had already been active in technology transfer is also illustrative. It could be argued that Bayh–Dole did not really impact on the legal structure of patent ownership at MIT, because MIT had an existing agreement with the government that generally gave it ownership of its inventions. However, Bayh–Dole did have a major impact because it pushed MIT as well as other universities to recognize that using inventions for the benefit of society could often be best accomplished through commercialization – which required the cooperation and risk-taking of the private sector. For example, a novel and patented chemical entity projected for use as a new pharmaceutical product would not benefit patients unless it were available commercially. Likewise, a newly-discovered material or alloy would not make aircraft lighter and stronger unless it could be made commercially.

Within one year of MIT's rethinking its licensing activities as a result of Bayh–Dole, the number of licences it issued increased by nearly 1,000%. During the next twenty years, the MIT Technology Licensing Office helped in the formation of nearly 800 new companies. A recent study of MIT spin-off companies showed that, if the active companies founded by MIT graduates formed an independent nation, their revenues would make that nation at least the 17th largest economy in the world.[6] While MIT clearly was spinning out companies before the passage of Bayh–Dole, the rate of new company formation based on MIT inventions and discoveries increased almost exponentially after its enactment.

Another point advanced by the critics as a basis for the increase of university patenting, apparently undercutting the influence of Bayh–Dole, was the large subsequent infusion of federal money, primarily through NIH, in support of life science research. However, the IPA programme and later the Bayh–Dole Act were critical incentives for recipient universities to file patent applications to protect important discoveries emanating from research supported by such funding. This would not have happened if NIH had retained its policy of taking title to inventions made in whole or in part with NIH funds.

Clearly, it was the incentive of patent ownership and the certainty of title accompanying ownership on which the private sector could rely in a licensing arrangement that spurred the increase of university patenting under the IPA programme. The patenting activity accelerated

Experience in the period before enactment of Bayh–Dole clearly established that ownership and management by universities of their inventions was clearly a superior policy than what had preceded it. For example, there had been an utter failure to commercialize university inventions when the National Institutes of Health had retained all rights to inventions made in whole or in part with federal money and adopted a non-exclusive licensing stance for those inventions. As the Comptroller General of the United States later testified: [3]

> '[. . .] we reported that HEW [Health, Education and Welfare] was taking title for the Government to inventions resulting from research in medicinal chemistry. This was blocking development of these inventions and impeding cooperative efforts between universities and the commercial sector.
>
> We found that hundreds of new compounds developed at university laboratories had not been tested and screened by the pharmaceutical industry because manufacturers were unwilling to undertake the expense without some possibility of obtaining exclusive rights to further development of a promising product.'

Therefore, a revolutionary approach was announced. As mentioned earlier in this paper, NIH established and adopted an administrative policy entitled the Institutional Patent Agreement (IPA). The IPA programme allowed universities with established technology transfer offices to own and manage inventions made with NIH funding. The programme began at NIH in 1968 and was so successful that the National Science Foundation adopted it in 1973.

This is how the Senate Judiciary Committee summarized the impact of the IPA programme:

> 'Since instituting the IPA program a number of potentially important new drugs initially funded under HEW research have been delivered to the public through the involvement of private industry in developing, testing, and marketing these discoveries. Prior to the IPA program, however, *not one drug* had been developed and marketed from HEW research because of a lack of incentives to the private sector to commit the time and money needed to commercialize these discoveries.' (Committee on the Judiciary, 1979, p 21, emphasis added.)

The programme continued to achieve success, but during the Carter Administration efforts were made to end it because of the personal philosophy of the new Secretary of Health, Education and Welfare (the agency is now Health and Human Services). That philosophy, much like the philosophies of many of the current critics of the Bayh–Dole Act, called for a return to case-by-case determination by NIH of whether university inventions made with its funding should be retained by NIH, or whether the ownership should be transferred to the universities for management. The Comptroller General testified that such determinations were taking 'from 8 to 15 months to complete' (Committee on the Judiciary, 1979, p 37). It was this movement to end the most successful patent policy in any federal agency that led universities to approach Senators Bayh and Dole, arguing that effective patent policies must have a legislative mandate so they could not be changed at the whim of a political appointee.

The potential to make changes in patent policies arbitrarily at the agency level, and the adherence to a non-exclusive licensing mandate, established a lack of predictability that was unnerving and unacceptable to potential industrial partners. Companies simply would not expend the sizeable amounts of private-sector time and money needed to turn patented university-based early-stage technologies into marketable products if the government could change the rules at a whim.

Shortly after introducing their bill, Senators Bayh and Dole held a press conference and gave examples of potentially important medical discoveries that were being strangled with red tape because of NIH's weakening of the IPA programme. Senator Dole compiled a list of '29 important medical discoveries that had been delayed from 9 months to well over a year before HEW were able to reach a determination whether or not the agency would retain patent rights. Follow-up review has shown no improvement in HEW's performance.' [4]

As a result, a rapid succession of Senators from across the political spectrum began to sign on as co-sponsors of the proposed Bayh–Dole bill.

While the current critics acknowledge the connection between the IPA programme and the Bayh–Dole Act, their dramatic impact on the commercialization of university inventions tends to be downplayed. For example, Sampat *et al* state:

> 'Bayh–Dole was passed in the throes of the ''competitiveness crisis'' of the 1970s and 1980s in the belief that the requirement to obtain IPAs or waivers and the frequently inconsistent policies of federal funding agencies regarding these agreements (especially regarding exclusive licensing) impeded technology transfer and commercialization of federally funded research results. In particular, the framers of the legislation argued that if universities could not be granted clear title to patents that

made by non-profit organizations and small business companies through the use of federal funds by:

- allowing ownership of such inventions to reside with those entities;
- providing universities with the discretion to license their inventions and discoveries under terms that encourage prompt commercialization through university–industry partnerships;
- stipulating that a percentage of royalties generated through successful commercialization efforts should be shared with inventors (royalties can also be used to pay for administrative costs associated with technology transfer, with the balance remaining designated to fund additional research or for educational purposes);
- providing that preferences should be given to licensing small businesses and requiring substantial US manufacturing where an exclusive license is granted for the USA;
- allowing the government to practise the invention royalty-free for governmental and treaty purposes; and
- allowing the government to 'march in' to require additional licensing if legitimate efforts are not being made by a licensee to develop the invention or in situations in which the licensee cannot produce sufficient quantities to meet a pressing national need (an action that has not been necessary in practice).

Congress, subsequent to the passage of the Bayh–Dole Act, created the Court of Appeals for the Federal Circuit. This destroyed many of the myths that afflicted the US patent system and thereby restored faith in the system and in the reliability of US patents. Congress also enacted the Small Business Innovation Research Act (SBIR)[2] to bring more technologically cutting-edge companies into government research. SBIR built on the assurances of the Bayh–Dole Act that small companies would own the inventions they made with federal funding.

The Bayh–Dole Act brought into play important factors and resources which other nations simply could not match:

(1) The US government funds far more R&D than other national governments – much of it in basic research, where breakthrough technologies are most likely to occur.
(2) This research is largely conducted at universities and other non-profit institutions that are world leaders in their respective technological fields.
(3) The Bayh–Dole Act permitted translation of this investment in science into practical applications which met important health, safety, environmental, food production and other critical needs.
(4) The USA is the acknowledged leader in entrepreneurship and the forming of small, high-technology companies which take the lead in driving new markets. Many of these companies are spun out of universities because of Bayh–Dole.
(5) The patents they own or license are a key asset of these small companies in attracting venture funding and competing in technology markets against larger companies. Those patents not only offer protection for their commercial position, but also the opportunity to recoup and reward the business risks that have been taken.
(6) The US patent system was thus a significant factor in spurring the revival of US competitiveness.

Even though the impact of the Bayh–Dole Act seemed evident as the USA enjoyed a reversal of fortune, as described in the *Economist Technology Quarterly* (2002) article cited above, a small group of academics began to question it. Their arguments can be summarized as follows:

- Bayh–Dole really was not that important. Universities were commercializing inventions anyway.
- Key data that Congress used to pass the Bayh–Dole Act – the small number of 28,000 government-owned patents that were licensed – were misleading.
- Bayh–Dole is not a model that should be adopted by developing countries because of its emphasis on patent ownership. Rather, what should be adopted is the pre-Bayh–Dole model of technology dissemination, stressing open access to scientific discoveries.

In the next section we review each of those charges in greater detail and in light of Ralph Waldo Emerson's admonition that, 'Numbers serve to discipline rhetoric. Without them it is too easy to follow flights of fancy, to ignore the world as it is and to remold it nearer the heart's desire.'

The Bayh–Dole Act and revisionist attacks

The Bayh–Dole Act of 1980 is now almost 30 years old. Few pieces of legislation have maintained their viability and significance in a rapidly changing environment for as long. However, it is being subjected to revisionist interpretations of its effects, benefits and the fundamental needs which caused its inception, passage and implementation.

Representative of these viewpoints is a paper by Bhaven N. Sampat (2002), later papers by critics such as Arti Rai and Robert Cook-Deegan (see, for example, So *et al*, 2008), and the writings of Rebecca Eisenberg (see Eisenberg, 1996). According to Sampat (2002, p 32),

taxpaying public. Reversing that trend, the Bayh–Dole Act encouraged the private sector to invest billions of dollars to develop inventions made in whole or in part with government-supplied (that is, taxpayers') dollars into market-ready products. This partnership between research universities and the private sector created millions of jobs for Americans, significant wealth for the USA and a higher standard of living, while helping to re-establish the USA as the technology innovation leader in a growing and increasingly competitive global economy.

Because the critics' recommended changes to Bayh–Dole would have a profound – and potentially very harmful – impact on the ability of the USA to respond to renewed international economic competition in the 21st century, any changes must be very carefully considered.

Therefore, it is our purpose to examine the charges levied against Bayh–Dole with the actual facts, and to set the record straight. Thus examined, the authors of this article firmly believe that the common revisionist arguments against Bayh–Dole are unfounded, finding a basis in anecdotal evidence or incorrect interpretations of data when logical conclusions should have pointed in another direction.

Reams of objective data exist to support the conclusion that the Bayh–Dole Act has greatly improved the commercialization of federally-funded research, that the system is working very well and that the public sector–private sector partnerships generated under the Act are essential both to the well-being and competitive position of the USA.

That these conclusions are correct is strongly reinforced by the fact that the USA's most serious economic rivals have adopted or are now adopting their own versions of Bayh–Dole to enable them to compete more effectively. Such imitation is the most sincere form of economic flattery. It would be ironic, indeed, if US policy makers chose this critical moment to weaken the well-established national innovation system which is respected throughout the world. This viable and functioning system is needed more than ever at this critical time to maintain a prosperous economy in an increasingly high-technology world.

Background

The USA, Europe and Asia are gearing up for a new round of competition to create wealth from the high-technology industries that are driving the international economy. In many ways, this is a replay of the 1970s and 1980s, when it appeared that Japan and Germany were riding the wave of the future – and many predicted that the USA's best days were behind it. At that time, the USA had lost its lead in traditional fields such as automotives, electronics, steel, and so on. Many experts confidently predicted that Japan and Germany would soon eclipse the USA in the few remaining markets where it led.

However, these predictions did not come true. Instead, the USA enjoyed a tremendous burst of entrepreneurial activity that restored its competitive advantage and laid the groundwork for decades of economic growth. This turnaround came through the adoption of many new policies that were hotly debated at the time. One of these was the passage of the Bayh–Dole Act of 1980. This is how the *Economist Technology Quarterly* (2002) summarized its impact:

> 'Remember the technological malaise that befell America in the late 1970s? Japan was busy snuffing out Pittsburgh's steel mills, driving Detroit off the road, and beginning the assault on Silicon Valley. Only a decade later, things were very different. Japanese industry was in retreat. An exhausted Soviet Empire threw in the towel. Europe sat up and started investing heavily in America. Why the sudden reversal of fortunes? Across America, there had been a flowering of innovation unlike anything seen before.
>
> Possibly the most inspired piece of legislation to be enacted in America over the past half-century was the Bayh–Dole Act of 1980. Together with amendments in 1984 and augmentations in 1986, this unlocked all the inventions and discoveries that had been made in laboratories throughout the United States with the help of taxpayers' money.
>
> More than anything, this single policy helped to reverse America's precipitous slide into industrial irrelevance.'

Further on the article summarized the law:

> 'The Bayh–Dole Act did two big things at a stroke. It transferred ownership of an invention or discovery from the government agency that had helped to pay for it to the academic institution that had carried out the actual research. And it ensured that the researchers involved got a piece of the action.
>
> Overnight, universities across America became hotbeds of innovation, as entrepreneurial professors took their inventions (and graduate students) off campus to set up companies of their own. Since 1980, American universities have witnessed a tenfold increase in the patents they generate, spun off more than 2,200 firms to exploit research done in their labs, created 260,000 jobs in the process, and now contribute $40 billion annually to the US economy.

'The competition for international students is intensifying,' said Madeleine F. Green, Vice President for International Initiatives at ACE. 'While the US remains the top destination for international students, the data reviewed in this paper draw a picture of a changing landscape and challenges that could threaten continued US success as a magnet for international students.'

Systemic practices also play a part. While recruitment efforts in the USA are carried out primarily by individual institutions, in the UK, for example, an ongoing education initiative aims to recruit an additional 100,000 international students by 2011 and to double the number of countries sending more than 10,000 students to the UK each year.

In the case of Germany, relatively low visa costs enhance its attractiveness as a location for study abroad. And France has streamlined its process for granting visas to international students, allowing them to extend their stay for an additional two years of work after they have completed their Master's degree. 'On the plus side,' said Madeleine Green, 'the visa application process in the US has improved considerably. However, some other countries make it easier than the United States does to stay after their studies.'

With regard to recruitment, the paper concludes that there is room for inter-institutional cooperation among US colleges and universities as well as additional collaboration between the government and the nation's post-secondary institutions.

It also identifies a growing trend of regionalization, with students staying in their region of origin to study, and profiles higher education centres like the United Arab Emirates and Qatar, which have established branch campuses to attract local and international students.

Sizing Up the Competition: the Future of International Postsecondary Enrollment in the United States can be downloaded from the ACE Website.

Source: American Council on Education, Press Release, 21 September 2009.

MONITOR

EU innovation review highlights the key challenges

The European Union and its member states have made good progress on innovation in recent years, but further action is urgently needed if the EU is to become the world's leading knowledge-based economy. This is the main finding of a Communication from the European Commission released in September. The Communication reviews progress on innovation in the EU and highlights key challenges.

'Innovation is the precondition for the creation of a knowledge-based, low-carbon economy,' states the Communication. 'Mastering this transformation is crucial to remain competitive in the globalized world and to achieve wider societal goals in a sustainable way under the pressure of demographic changes, the climate challenge, scarce resources and new security threats.'

The Commission accepts that there has been progress in various areas. Most member states, it says, have improved their innovation performance and the innovation gap between the EU and its main competitors (the USA and Japan) has narrowed.

The most innovative countries share common features. They are typically spending above the average on education, training and lifelong learning, record the highest percentages for R&D as a proportion of GDP and have programmes in place to support the take-up of new technologies and products. 'Experience also shows that these countries are better prepared to make use of the exchange of best practices and to learn from others,' notes the report.

Legislative changes, new funding opportunities, favourable tax schemes and initiatives and programmes to improve links between business and universities have all enabled considerable progress in R&D investment and activity. However, warns the Communication, there remains much room for improvement. In many countries, there is a need for a new mindset. According to the report, the value of innovation and entrepreneurship is not yet sufficiently recognized in Europe, and the failure that sometimes results from them is still stigmatized.

Furthermore, the lack of a Community patent means that it is more expensive to protect intellectual property in Europe than it is in the USA or Japan. 'It is high time to change this situation,' warns the report.

The Communication also calls for improved coordination of policies designed to boost innovation at regional, national and international levels. In addition, despite the many EU funds available to support research and innovation activities, many stakeholders are put off applying for them by the amount of bureaucracy involved: companies need simpler and quicker procedures.

'The analysis of the progress achieved in recent years shows that the EU has rightly identified innovation as a key driver for a prosperous future,' the Communication concludes. 'However, making the EU a vibrant space for innovation requires continuous attention and calls for a better exploitation of the potential of the partnership between the Union and its member states by taking more focused and better coordinated action at all levels.'

Source: CORDIS, News Release, 3 September 2009.

BHEF launches new resource centre for educational philanthropy

The US Business–Higher Education Forum (BHEF) has released a new online resource centre for corporations investing in education.

StrategicEdSolutions℠ details strategies, tools and successful programmes to help corporations and others make more effective philanthropic investments in education. The site also provides an interactive forum for corporations and foundations to share best practices.

'Our members – Fortune 500 CEOs, university presidents and foundation leaders – asked us to identify effective educational practices and programmes that would help them and others improve the impact of their education philanthropy,' said Brian Fitzgerald, Executive Director of BHEF. 'We know that philanthropy is a significant source of innovation to improve student achievement and college readiness. The strategies and programmes featured on StrategicEdSolutions.org have a strong record of delivering results, and we are excited to shine a spotlight on these best practices so other philanthropies can learn from and replicate their success.'

David Jones, Chairman of Humana Inc and BHEF member, welcomes the initiative, noting that 'too often, corporate CEOs lack reliable information on which to base their education philanthropy decisions. This new site responds to this need for information through practical examples, thorough research and on-the-ground strategies'.

Source: BHEF, Press Release, 16 September 2009.

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