CHAPTER

University-Business Partnerships for a Knowledge Society

James J. Duderstadt and Luc E. Weber

The Glion V Colloquium brought together university and corporate leaders from Europe and the United States to discuss how higher education and the business sector could collaborate more effectively to achieve and sustain economic growth, social cohesion, and well-being in an ever more competitive global, knowledge-driven economy. As in past Glion meetings, the discussions involved both round-table discussions of papers prepared in advance and presented by the participants, as well as informal discussions throughout the three-day meeting in Glion above Montreux, Switzerland. The papers presented at the meeting have been included in this book. This final chapter is intended both to provide a sense of the broader discussions and to identify several of the most important themes and conclusions of the meeting.

The working sessions were organized around several topics: an overview of the implications of a knowledge-intensive global economy for business, higher education and government; the changing nature of the creation and transfer of knowledge from research universities to industry and thence society; the differing perspectives of university-business relationships as seen both by universities and the business community in Europe and America; the increasingly critical role played by advanced education in producing human capital, particularly in key fields such as science and engineering; and the importance of the social sciences and humanities in achieving social cohesion in increasingly multicultural and multi-ethnic societies, while promoting sustainable development. Although the papers included in this book have been organized

around these subjects, as were the working sessions, in this summary it seems more appropriate to adopt an organization based on the key themes that arose from the working sessions and other discussions throughout the meeting:

- The challenges of a global, knowledge-driven economy;
- The differing perspectives of business, universities and governments in Europe and America;
- More fundamental concerns;
- The need for new paradigms;
- The implications for higher education;
- The implications for university-business relationships.

THE CHALLENGES OF A GLOBAL, KNOWLEDGE-DRIVEN ECONOMY

We live in a time of great change, an increasingly global society, knitted together by pervasive communications and transportation technologies and driven by the exponential growth of new knowledge. A global, knowledge-driven economy places a new premium on education and workforce skills and education, challenging both ageing populations in Europe, North America, and parts of Asia, and the youth-dominated populations of the developing world. Social cohesion remains an ideal in many countries that continue to be challenged by ethnic, religious and regional disputes, while the great disparity in wealth and power around the globe creates new geopolitical tensions through conflict and terrorism. Further population growth and economic development threaten global sustainability through the depletion of natural resources such as petroleum and the impact of human activities on climate.

More fundamentally, we are evolving rapidly into a post-industrial, knowledge-based society, a shift in culture and technology as profound as the shift that took place a century ago when our agrarian societies evolved into industrial nations (Drucker, 1993). A radically new system for creating wealth has evolved that depends upon advanced education, research and innovation, and hence upon knowledge-intensive organizations such as research universities, corporate R & D laboratories and national research agencies.

The implications for discovery-based learning institutions such as the research university are particularly profound. The knowledge economy is demanding new types of learners and creators. Globalization requires thoughtful, interdependent and globally identified citizens. New technologies are changing modes of learning, collaboration and expression. And widespread social and political unrest compels educational institutions to think more concertedly about their responsibility in promoting individual and civic development, democratic values and social cohesion. Institutional and peda-

gogical innovations are needed to confront these dynamics and ensure that the canonical activities of universities — research, teaching and engagement — remain rich, relevant and accessible.

Both developed and developing nations are investing heavily in education and research, restructuring their economies to create high-skill, high-pay jobs in knowledge-intensive areas such as new technologies, professional services, trade and health care. From San Diego to Dublin, Helsinki to Bangalore, there is a growing recognition throughout the world that prosperity and social well-being in a global, knowledge-driven economy require significant public investment in knowledge resources. That is, regions must create and sustain a highly educated and innovative workforce, supported through policies and investments in cutting-edge technology, a knowledge infrastructure and human capital development. Moreover, social challenges such as the healthcare costs of ageing populations, social diversity and retirement pensions will require comparable investments in the social sciences and humanities. Nations both large and small, developed and developing, are beginning to reap the benefits of such investments aimed at stimulating and exploiting technological innovation, creating serious competitive challenges to American and European industry and business both in the conventional marketplace (e.g., Toyota) and through new paradigms such as the global sourcing of knowledge-intensive services (e.g. Bangalore).

These imperatives of the knowledge economy provide the context for the discussion of university-business relationships, since the intensifying nature of global competition and importance of technological innovation will demand significant changes in the way research is prioritized, funded, conducted and transferred to society, perhaps shifting university emphasis towards use-driven basic research and innovation; the way we educate and employ professionals such as scientists and engineers; policies and legal structures in areas such as intellectual property; strategies to maximize contributions from institutions and workforce development (e.g., universities, corporate R & D laboratories, government agencies); and in the very nature of social institutions such as corporations, governments, NGOs and universities and the ways in which these interact with one another.

The increasing social needs of an ageing population and a slowdown in economic growth, coupled with the increasing competitiveness of rapidly growing Asian economies, have stimulated a number of European nations to adopt the Lisbon Agenda (2000) "to become the most competitive and dynamic knowledge-based economy with more and better jobs and social cohesion" by "mobilizing the brainpower of Europe". While this establishes major investments in higher education and research as priorities, with the goal of bringing Europe up to the level of the United States by 2010, there are serious concerns that such an ambitious objective may be inconsistent with the low economic growth of national economies (*The Economist*, 2005). Furthermore it will

likely require major structural changes in how European universities are organized, governed and financed.

While the long-standing partnership among research universities, business and government in the United States continues to maintain global leadership in measures such as the percentage of GDP invested in R & D, the number and productivity of researchers, and the volume of high-tech production and exports, there are several worrisome trends: the decline in federal funding for basic research, the imbalance in the national research portfolio, with roughly two-thirds of university research now in the biomedical sciences; the erosion of basic research in both corporate R & D laboratories and federal agencies; the increasing complexity of intellectual property policies; and an inadequate supply of scientists and engineers in the wake of the changing immigration policies in the aftermath of the terrorist attacks of 2001. Of particular concern is achieving adequate investment in the new knowledge (research), human capital (education), and infrastructure (institutions, laboratories, networks) and policies (tax, intellectual property) necessary to sustain America's leadership in technological innovation, now challenged by corporate practices such as global sourcing of R & D, innovation and design to rapidly emerging economies in Asia.

Yet there is an additional caution here: universities have a broader public purpose than merely responding to the economic needs of society. Universities defend and propagate our cultural and intellectual heritage; they are the source of leaders of our governments, commerce and professions; and they provide through educational opportunity the skills necessary to enable social well-being and justice. They are complex social institutions characterized by great diversity, reflecting their adaptation to regional needs and challenges. While the current imperatives of the global economy have stimulated governments to encourage more competition among universities through market forces, there may be instances in which this market orientation does not align well with broader social needs.

A global knowledge-driven economy is challenging all of the assumptions and practices of the past — geopolitical, economic, information and disciplinary. It is becoming apparent in both Europe and America that our current partnerships, programmes and policies for the conduct of research and advanced education must be transformed to better serve the knowledge economy. This, then, provides the challenge, within a context of issues such as the balance between public vs. private investments, competition vs. cooperation, and public policy vs. market forces.

EUROPE AND AMERICAN PERSPECTIVES

There are many similarities between the European and American perspectives of the challenges and opportunities presented by a global, knowledge-driven

economy. Both European and American companies recognize that they can no longer rely solely upon internally conducted R & D, both because of shareholder pressures and the increasing pace of technological change. Instead companies must establish networks of research partnerships in both the public and private sectors. Corporate leaders see relationships with research universities as critical in providing access to key sources of basic research and advanced. Yet there are growing concerns about the difficulty in establishing and sustaining these relationships.

The concern most frequently expressed by American companies is the difficulty in negotiating intellectual property rights with universities, which now seek to capture the considerable value of the intellectual property generated by campus-based research and attempt to defend their ownership and access to potential licensing income with complex contracts and litigation. Since many companies view intellectual property ownership and access as a defensive measure to protect proprietary knowledge rather than generate new revenues (although the pharmaceutical industry is an exception), they are frustrated by the time and expense it takes to negotiate research relationships with universities. Some companies have become so frustrated that they have now shifted their attention to universities in nations with less aggressive intellectual property objectives (e.g., China, Taiwan, India).

Business leaders noted that there has been considerable success in negotiating company-to-company relationships in sharing technology even with competitors, in part because there was a body of practice to rely upon, in contrast to company-to-university relationships, in which industry felt that the anarchy characterizing higher education meant that each negotiation began by trying to reinvent the wheel. Several industrial participants suggested that the private sector would simply not tolerate interminable discussions about intellectual property issues that showed little promise of early resolution. They urged European universities not to emulate the American practice and instead to develop a more positive and structured approach to these issues, e.g., through the intellectual property guidelines developed — among others — by the European Research Management Association (EIRMA) (2004) and the European University Association (EUA).

But university leaders also expressed frustration with the current relationships with business. As one university leader noted, many companies have downsized or eliminated corporate R & D and are now turning to research universities to fill the void. Of course, part of the challenge here is that the highly directed research sought by industry frequently does not align well either with university capabilities or faculty interests. But there is also a cultural issue, since rather than approaching this relationship as the procurement of needed technology and human capital, many companies view their support instead as more philanthropic than as a strategic quid pro quo relationship

with a critical supplier. All too frequently companies suggest that their corporate taxes already have paid for the university infrastructure and personnel necessary to conduct the research, although even a superficial analysis of the financing of higher education quickly reveals the fallacy in this perspective.

There seems to be a growing awareness that, beyond the inevitable frustrations with particular issues such as intellectual property rights and full economic recovery of research costs, there were deeper issues that related to the strategic nature of the relationship to both the company and the university. The most successful examples of industry-university relationships seemed to arise when companies had a carefully designed strategy for managing their relationship with universities, perhaps through separate subsidiaries much as they manage business-to-business technology alliances. Similarly, universities need to perceive true value-added in the relationship, particularly in an era in which they were expected to generate most of the support for their teaching, research and service activities from the marketplace. As we will note later, this is particularly true in the United States, where many universities have concluded that their maximum contribution to society — and benefit to the institution — is through the spin-off of new ventures that rely heavily upon intellectual property ownership to attract private investment capital. This is a much deeper issue, since it suggests that at least some universities see their mission more as creating new industry than supporting existing industry.

Governments also have their own perspectives of these relationships. In both Europe and the United States there has been a gradual erosion in public support of universities — at least on a per student basis — associated both with the desire to provide higher education opportunities to an increasing fraction of the population (massification) and because of the shifting priorities of ageing populations (health care, security, tax relief). Yet, simultaneously, there has been growing awareness in recent years that a global, knowledge-driven economy demands enhanced capacity in research, innovation and in advanced education. The challenge is how to achieve this.

Many national and regional governments continue to view public support of higher education and research not as an investment, but rather as an expenditure competing with other current needs (e.g., health care, retirement pensions). Politicians continue to call for universities to do more with less through restructuring and enhanced productivity, suggesting that perhaps stimulating more competition among institutions will stimulate both quality and capacity even in the absence of additional investments. They suggest that by challenging faculty privileges (tenure, academic freedom) or restructuring universities (mission differentiation, competition for resources), higher education can be made far more responsive and efficient. While it is certainly true that cost-containment and accountability are important issues, it is also the case that in many nations, particularly in Europe, universities can rightly

counter-argue that the main problem for them is that they are over-regulated and under-funded. On average, the total investment on higher education and research in Europe is roughly 4% of GDP, compared to 6% of GDP in the United States. It is unlikely that efficiency alone could close this funding gap that has been key to the faster development of American higher education and research over the last 20 to 30 years.

European university leaders expressed many concerns about the financial vulnerability of their institutions, still primarily dependent on tax support without appreciable student fees or gift income, relatively small, and insufficiently entrepreneurial compared to the massive research universities in America, with relatively weak governance incapable of driving major changes or exerting strong leadership. This situation was made even more difficult by the necessity of extending education to an appreciable fraction of the workforce in European nations, an imperative of the global economy. The current model for financing higher education in Europe, almost entirely dependent upon public tax support, is simply incapable of sustaining massification while achieving world-class quality. Currently the investment in higher education in European countries ranges from 0.9% to 1.8% of GDP, of which only approximately 10% comes from private sources (e.g., student fees). In sharp contrast, the United States spends roughly 2.5% of GDP on higher education, of which over two-thirds comes from private support, including student fees, private gifts, and income-generating activities (e.g., the licensing of intellectual property). Since tax revenues are already stretched thin sustaining Europe's strong social programmes, it seems unlikely that the E.U. and other developed European nations will be able to provide the advanced educational opportunities required by a knowledge-driven economy without appreciable changes in tax policies (to encourage private philanthropy) and student/family expectations (to accept significantly higher student fees).

In Europe, the goal of the Lisbon agenda to increase the level of spending in research to 3% of GDP, with two-thirds being invested by the private sector, would depend on increasing by 70% the number of researchers to 700,000, which is simply not manageable without a strong influx of scientists from other countries in East and central Europe, Asia and Latin America. Since most of the research in E.U. countries is done in the northwest region of Europe whose origin is around Vienna, this very fact would have dramatic consequences on the less developed countries in eastern, central and southern Europe.

Yet, while perhaps more generously supported from public and private sources, numerous recent studies have concluded that even the current United States research and higher education portfolio has neither the magnitude nor the balance of investment necessary to address the nation's key priorities — national security, public health, environmental sustainability, or

economic competitiveness (Council on Competitiveness, 2004; National Academies, 2005). Even in the highly competitive American higher education enterprise, there is a growing concern about whether the universities have sufficient agility, capacity and quality to serve the needs of their regions or the nation itself as they face an increasingly competitive global economy.

There were also serious concerns expressed, particularly by the American participants, about the availability of graduates in knowledge-intensive areas such as science and engineering. Eroding student interest in science and mathematics and the weakness of K-12 education have led to a situation in which engineering students comprise less than 5% of American college graduates, compared to 12% in Europe and over 50% in some Asian countries. The United States has traditionally been able to compensate for this domestic shortfall by using its high quality universities to attract talented students in science and engineering from other countries. However in the wake of 9/11, a tightening of immigration policies, coupled with the increasing efforts of other nations to compete for foreign university students, has threatened this supply.

MORE FUNDAMENTAL ISSUES

There are important similarities between Europe and America as they strive to compete in the global economy. Although both European nations and American states have largely taken higher education for granted for the past several decades, allowing an erosion in public support per student as other social needs, such as health care and retirement pensions, were given higher priorities, today there is a growing recognition that a substantial reinvestment in research and advanced education is necessary for economic prosperity and security in a knowledge economy. In Europe, such initiatives are both pan-European like the European Higher Education Area (e.g., the Bologna process) or at the level of the European Commission (e.g., the Lisbon agenda), with initiatives such as the European Research Area (better integration of National and European research policies and the project of the European Research Council), with a target of increasing R & D to 3% of GDP by 2010. In contrast, the United States response to the challenge of the global knowledge economy thus far is dominated more by rhetoric than commitment at either the federal or the state level.

The Lisbon agenda tends to use as a benchmark the United States investments in higher education and research, while the Bologna process and ERC tend to emulate characteristics of the American research universities (e.g., standardizing university degrees upon the bachelors, masters, and Ph.D., while basing the envisaged European Research Council research programmes on competitive, peer-reviewed grants much like the U.S. National Science Foun-

dation). Ironically, the United States today is not looking back over its shoulder to Europe, but rather looking ahead at the competitive threat posed by the explosion of high-quality research and education in science and engineering in Asia, particularly China and India.

There are several important differences in the approaches taken by European and American universities towards knowledge transfer from campus laboratories into society and their relationships with industry. European universities continue to embrace a linear model of knowledge transfer, from basic research to applied research and development and finally into products and services. Hence their greatest academic strengths are in the more mature disciplines such as physics, chemistry and mathematics. American universities are restructuring themselves to adapt to a highly non-linear model of knowledge flow, increasingly characteristic of technology-driven economic development. Both universities and funding agencies are blurring the distinction between basic and applied research, building the multi-, inter- and cross-disciplinary programmes necessitated by technologies such as information-, bio- and nano-technology that evolve at exponential pace (e.g., Moore's Law). While European universities and industry strive to build enduring collaborative research networks in response to national or E.U. objectives and according to their own specific comparative advantage, market-driven research universities in the United States tend to focus instead on regional technology-driven economic development through spin-off and start-up companies, giving highest priority to building new industries in cutting-edge technology (info-bio-nano) rather than sustaining older industries (e.g., manufacturing). While Europe attempts to build the university, national and EU structures and policies to produce the research and advanced education required by a knowledge economy, the anarchy of the American marketplace prefers more of a "just do it" philosophy.

The American participants reviewed the history of several of the more prominent stories of technology-driven economic development in the United States: Route 128, the Research Triangle, San Diego and Austin). It was suggested that just as "all politics is local", "all economic development is regional". In each case, the trigger event was the phenomenal success of a start-up company spun off from faculty research, which created the wealth (and the wealthy entrepreneurs) that was ploughed back as venture capital into the next round of start-ups, e.g., Digital Equipment Corporation in Boston, SAS in North Carolina, Qualcomm in San Diego, and Dell Computers in San Diego. There were notable differences, of course. The Austin economic miracle involved a partnership between the University of Texas and state government, along with public funding, to attract key research organizations (the Microelectronics and Computer Corporation); San Diego relied primarily on private capital; Stanford and Austin both made a strategic asset of their sub-

stantial land holdings. There are early signs that similar strategies of new high-tech business development are beginning to appear in Europe around several leading research institutes and universities such as the Fraunhofer Institutes and the Swiss Federal Institute of Technology.

Yet at the core of all of these efforts are world-class research universities that serve as magnets to attract top talent, along with the high quality of life characterizing their surrounding communities that kept talent in the region. These universities were characterized both by focused excellence, as well as intellectual breadth that allowed them to span many fields, engaging in both basic and applied research of the highest quality. In each case, university, industry and government leadership were well aligned and capable of working together at the highest level. Each situation began with a "big hit" that then provided both the role model and the venture capital stream for subsequent start-ups.

There is one more key feature of these success stories that may explain much of the frustration occurring today in university-business relations. In each case, ownership of key intellectual property was critical to attracting the necessary private capital for successful start-ups. Both universities and faculty entrepreneurs were aggressive in capturing and retaining intellectual property rights. In the United States, research universities have embraced a sophisticated, non-linear model of knowledge transfer, where they increasingly view their primary missions — not to mention their greatest rewards — as creating new industries rather than supporting old companies. Put another way, American universities see their greatest value to society and their greatest institutional payoff in Schumpeter's "creative destruction", building the new industries that will eventually devour the old. Hence it is not surprising that established companies seeking cooperative relationships are increasing frustrated by the priorities American universities give to spin-offs and start-ups requiring aggressive negotiations to retain the intellectual property rights necessary to attract private investment. Although some companies have adopted a near-term strategy of off-shoring their R & D activities to nations with less aggressive intellectual property demands, over the longer term this will deprive them of access to many of the world's leading research universities.

More cynically, one might even question the strategy that many established companies have adopted to dismantle their own internal capacity for R & D and instead outsource R & D through cooperative relationships with research universities. Rather than welcoming them with open arms, many American universities are negotiating with them just as other companies would, insisting on beneficial intellectual property rights and adequate support of research costs. Cooperative arrangements with universities will have to have sufficient benefits to compete with spin-off activities, either through direct financial support of the university by industry or through indirect support through

industry's ability to influence government policies for investing in R & D and higher education. This brave, new world of peer-to-peer university-industry relationships has been a shock to many companies that have long viewed support of higher education as philanthropy rather than a quid pro quo strategic technology alliance!

In contrast, as we could expect from the small size of most countries, European universities are less focused on regional economic development and more aligned with national policy, seeking cooperative relationships with established industry and less inclined to be aggressive in negotiating intellectual property rights. To some degree the lower number of start-up companies may be due to the more limited autonomy and agility of government-funded European research universities, thereby inhibiting risk-taking and entrepreneurial activities, as well as due to the limited availability of venture capital. Concern was also expressed that such autonomy might be further eroded by the decreasing trust in higher education institutions as well as due to E.U. integration, particularly if it introduces additional layers of bureaucracy.

While differences in university funding, governance and leadership are certainly factors in explaining the contrasts between university-business relationships in Europe and the United States, of far more importance are more fundamental perspectives of mission. The E.U. and national strategies are to build strong partnerships and collaborative networks to sustain existing industry, relying on a more traditional linear model of technology transfer, albeit with higher transactions costs. The contrasting U.S. strategy is to take advantage of market efficiencies by building competitive environments and providing universities with the autonomy and agility to create new companies and new industries through non-linear models of technology transfer.

THE NEED FOR NEW PARADIGMS

Much of the discussion at the Glion V sessions concerned the exploration of new paradigms for both higher education and its interaction with industry and broader society. It was noted that the organization of faculty within the university was changing, as communications and transportation technologies have enabled scholars to form global research communities, largely decoupled from universities. To some degree the faculty exhibits an uncertainty principle similar to that of quantum physics, since the more one attempts to determine their location, the less one is able to influence their calendar. Faculty loyalty long ago shifted from the university to disciplines, and now it is shifting again to problem areas. Discussions raised some important questions, for example, what is the best way to organize faculty expertise? What should the relation between the university and the faculty member be? What is the true value-added of a university?

The Fraunhofer Institutes provide an interesting example of the changing nature of technology transfer, innovation and economic impact. The traditional linear model began with attracting the best faculty to a research university, providing them with adequate resources, preferably through competitive grants, and then disseminating the results of research widely. However beyond the fact that this model does not scale easily and can take years, if not decades, to build institutional capacity, simply hiring the best people does not always work since experts are highly mobile. Furthermore, first-class research does not necessarily imply innovation. A variation on the traditional approach is to hire top talent and focus major investments only in highly specialized areas, relying on networking with other top programmes to broaden capacity. But this model can be inherently unstable, since while it builds strength in building spires of excellence, these may not yield the necessary ingredients for innovation in a rapidly evolving knowledge economy.

The experience of the Fraunhofer Institutes suggests an alternative approach of financing cooperative projects to create clusters, with an emphasis upon financing new ventures and promoting innovative markets through tax breaks and the active management of intellectual property. More broadly, while the benefits of innovation are widely recognized, it is hard to achieve an innovative economy. Success requires years of effort and a visible plan, acceptable to both the pubic and private sectors, which matches local strengths and achieves commitment for the long haul. While high-quality research universities are important, they should avoid technology determinism and instead bring not only basic and applied research, but also stimulate financial acumen and enlightened public policies.

Ireland and Finland provide vivid demonstrations of how effective public policies and targeted investments can create an environment in which innovation can flourish. Ireland's efforts to bootstrap to build a prosperous knowledge economy are particularly interesting. It involved an investment in human capital (e.g., universal secondary education in the 1960s and postsecondary education in the 1990s), tax policies that lowered taxes on corporate earnings, and social policies such as a national healthcare system that minimized cost to business. Today Ireland continues to invest heavily in knowledge generation through increasing university R & D (already at a greater per capita amount that the United States and allocated using international peer review) and stimulating corporate R & D through favourable tax treatment. The combination of a highly educated workforce, investment in R & D, attractive tax policies and supportive social policies has both attracted and created high-tech industry, while transforming the nation into one of Europe's most prosperous.

Although difficult to predict, it was also likely that the paradigm of the university itself was changing. It was noted that fundamental changes in higher education had occurred in the United States roughly every 50 years, from the

colonial colleges of 1800 to the land-grant public universities in 1850 to graduate and professional education in 1900, to the federally supported research university in 1950. It was suggested that the next stage might be the "meta-university", in which rapidly evolving information and communications technologies, coupled with "open source/open content" philosophies, provide a platform for global universities. Ongoing experiments, such as MIT's Open CourseWare, DSpace, and Open Knowledge Initiative projects, the SAKAI Middleware Project, and Google's project to digitize and distribute online the massive holdings of several of the world's leading libraries, suggest that the future of the university is unpredictable indeed.

Hence many participants believed that it was foolhardy to constrain university evolution through detailed planning. Instead it was best to create a competitive environment, a level playing field where quality was rewarded, and in which the cream would rise to the top. Excellence comes about from backing potential winners, not from rescuing losers. While building capacity was an important role of government, it should not be confused with stimulating research excellence.

THE IMPLICATIONS FOR RESEARCH UNIVERSITIES

Although there are very significant differences between research universities in Europe and the United States, there is a strong commonality in the central role these institutions are expected to play — indeed, must play — in the knowledge economies sought by their regions and nations. This role of providing well educated graduates and knowledge professionals, research, innovation, and entrepreneurial energy will demand certain changes in how these critical institutions are structured, financed, governed and led.

The challenges are somewhat different in Europe than the United States. First, it has become increasingly clear that, with public tax support of higher education constrained by the burdens of generous social services and weak economic growth, further massification will only erode the support of research universities. While increasing student fees and modifying tax policies to encourage philanthropic support of higher education will be challenging, many participants saw no alternative to enhanced private support if Europe's universities are to remain competitive.

Stratification is also a challenge to higher education, where broad distribution of resources leads to the illusion that the E.U. has 1,000 quality research universities, with the result being that only a handful are truly world-class. Too many universities are chasing the same institutional mission as world-class research universities, where their small size and modest resource base makes this clearly impossible. There needs to be a greater transparency, realism and differentiation by mission.

Another major challenge has to do with the relative absence of comprehensive research universities in Europe with a critical mass in most disciplines, spanning the full spectrum of academic and professional disciplines and missions, as hundreds do in the United States and an increasing number strive to do in Asia. The increasingly non-linear paradigms of knowledge transfer, in which not only do disciplines interact in surprising ways, but there is extensive overlap between basic and applied research and development — and hence academic disciplines and professional education (e.g., basic life sciences and clinical practice in medicine or quantum physics and electrical engineering), demand universities of sufficient intellectual breadth and capacity. This may be one of the reasons that, although many European universities are renowned for leadership in selected areas of basic research, they are less well known for innovation or entrepreneurial activities. Although the limited intellectual span of most European universities can be addressed to some degree through the formation of collaborative alliances, in the longer run it is likely that only through the merger of many existing institutions will Europe be able to create large comprehensive universities that are competitive on a global level.

A third challenge is creating a competitive environment that encourages the evolution of world-class institutions. Clearly this is an objective of the envisaged European Research Council, which aims to implement a peer review system that recognizes excellence and focuses resources accordingly. World-class research universities arise from a resource allocation and reward system based on absolute excellence, as determined by peer review on a global level. Yet shifting from an egalitarian to a more elitist system that builds and sustains a small number of world-class research universities, likely excluding some E.U. nations entirely, will encounter political difficulties, just as it has among the have-not states in the United States. Some participants were concerned that seeking to recognize a relatively small number of research universities could lead to a policy of ossification rather than a development and recognition of research potential. Striking the right balance between focusing resources to build truly world-class research universities, while building broader research capacity in higher education, will be a public policy challenge. To these challenges to European universities must be added the burdens of long-standing traditions of governance and management, combined with relatively powerless leadership that is currently unable to provide the autonomy and agility to compete effectively in the global marketplace for talent, resources and reputation.

American universities are also facing major challenges that will demand significant changes in structure and policy if they are to play the role they must in a knowledge society. Participants suggested a mosaic of concerns that, when viewed more broadly, suggests a national trend toward short-term think-

ing and preserving the status quo. Recent modifications in immigration policies, export controls and restrictions on so-called "sensitive, but unclassified" information in the wake of 9/11 are seriously hindering both access to foreign students and faculty and international cooperation, long key to the quality of American research universities (Committee on Science, Engineering, and Public Policy, 2005). Federal research policy, increasingly distorted by the massive increase in the funding of biomedical research demanded by an ageing population, and now seriously constrained by the budget deficits arising from ill-considered tax cuts and the build-up of national defence, threaten the research capacity of U.S. universities. In this climate, researchers are becoming increasingly risk-adverse, in an effort to secure and sustain research grant support. Furthermore, in some fields, such as biomedical research, a feudal culture has evolved in which young investigators are held in a subservient and underpaid postdoctoral role for a decade or more, effectively as the migrant worker population sustaining the research enterprise until well into their professional careers.

The highly competitive nature of higher education in America, where universities compete for the best faculty, the best students, resources from public and private sources, athletic supremacy and reputation, has created an environment that demands excellence. However it has also created an intensely Darwinian, "winner-take-all" ecosystem in which the strongest and wealthiest institutions have become predators, raiding the best faculty and students of the less generously supported and more constrained public universities and manipulating federal research and financial policies to sustain a system in which the rich get richer and the poor get devoured. More serious is a national climate in which higher education is increasingly seen as more a personal benefit than a public good benefiting all of society, which, in turn, leads both politicians and the public at large to view its support as just another expenditure rather than an investment in the future. Today in the face of limited resources and more pressing social priorities, the century-long expansion of public support of higher education has slowed to a halt and actually has been declining for the past two decades. While there may be no perceived crisis in the individual elements of this mosaic of concerns, the larger pattern is quite disturbing, and certainly threatening to the nation's efforts to adapt to a hyper-competitive global knowledge economy.

THE IMPLICATIONS FOR UNIVERSITY-BUSINESS RELATIONSHIPS

There is no single model for successful university-business relationships. Local circumsrances can often dictate the nature of this interaction. For example, in those regions where the primary goal is high-tech economic development

through spin-offs and start-up companies from university research activities (e.g., North Carolina's Research Triangle or California's Silicon Valley), university ownership of intellectual property becomes very important. This can frustrate the efforts of established industry to build research partnerships, since the resulting negotiations can be complex, time-consuming and dominated by lawyers.

To be sure, there are other regions — and nations — where such intellectual property rights are not so critical, and traditional research partnerships are easily negotiated. Yet a business strategy of building R & D networks that avoid contentious intellectual property negotiations, perhaps even off-shoring these to developing nations such as India and China, could well be self-defeating in the long run, since it would deprive companies of access to the leading research programmes. Furthermore, it is likely that most regions — and institutions — will emulate the success of the American spin-off-start-up entrepots and eventually become more aggressive in intellectual property negotiations.

An additional challenge will be the changing nature of the university itself. As innovation and entrepreneurial activity become more significant priorities for academe, stimulated both by the increasingly non-linear nature of knowledge creation and transfer, as well as by the needs of a knowledge economy, universities are likely to strive for a different mix of basic and applied research and development (Council on Competitiveness, 2004). Of course, this is not a new phenomenon, as evidenced by the agricultural experiment stations created by the American land-grant university movement and later the comprehensive academic medical centres, combining basic research, medical training and clinical care. In fact, some universities may even attempt to emulate successful external efforts like the Fraunhofer Institutes in Europe or the national laboratories in the United States.

Hence it is important for industry to recognize that their university partners will increasingly resemble other business partners rather than the traditional ivory towers of academe. That is, it could well be that established companies and universities would be more successful in building research alliances according to well established business-to-business relationships, rather than traditional university-industry models. This will require a more strategic approach to university relations on the part of the business community, viewing these as more as quid pro quo alliances providing both knowledge (basic research, technology and perhaps even innovation) and human capital (graduates in science, engineering, business and other high-demand fields) in return for comparable financial support and technology sharing than a philanthropic relationship. Universities, in turn, will be held more accountable for honouring the terms of the negotiated relationship, requiring faculty commitment, and accepting some degree of financial liability. Clearly (and, unfortunately inevitably), lawyers will continue to be an important part of this negotiation in the United States.

It is likely that new types of organizations will be necessary to create and sustain such alliances. Existing industry may find it useful to create new companies or organizations for the strategic management of such technology alliances, behaving more as start-up ventures than long-established enterprises. Universities could consider more flexible structures similar to the academic medical centre for building alliances with industry for basic and applied research and innovation such as the Discovery-Innovation Institutes recently proposed by the U.S. National Academy of Engineering.

Let there be no doubt, however. In a global, knowledge-driven economy the keys to economic success are a well educated workforce, technological capability, capital investment, and entrepreneurial zeal — a message well understood by developed and developing nations alike throughout the world that are investing in the necessary human capital and knowledge infrastructure. Key in this effort will be building strong relationships between universities, as the source of new knowledge and the well educated graduate, and industry, with the goal of adding value to the knowledge and human capital necessary to produce competitive products, processes and services to achieve profit and social prosperity in a global economy.

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