Higher Education and Economic Development

LITERATURE REVIEW

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CHET

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Acronyms and abbreviations

BEH	Botswana Education Hub
BWP	Botswana Pula
CHET	Centre for Higher Education Transformation
CoET	College of Engineering and Technology
DPF	Department of Planning and Finance
FDI	Foreign direct investment
FTE	Full-time equivalent
GCI	Global Competitiveness Index
GDP	Gross domestic product
GER	Gross enrolment ratio
GII	Global Innovation Index
HEA	Higher education attainment
HERANA	Higher Education Research and Advocacy Network in Africa
HESLB	Higher Education Students' Loans Board
ICT	Information and communication technologies
IMF	International Monetary Fund
ITRI	Industrial Technology Research Institute (Taiwan)
LISP	Local Innovations System Project (Massachusetts Institute of Technology)
MDG	Millennium Development Goal
MIT	Massachusetts Institute of Technology
MSTHE	Ministry of Science, Technology and Higher Education
NGO	Non-governmental organisation
NUFFIC	Netherlands Organisation for International Cooperation in Higher Education
OECD	Organisation for Economic Co-operation and Development
PPF	Production possibility frontier
PPP	Purchasing power parity
R&D	Research and development
SADC	Southern African Development Community
SET	Science, engineering and technology
SME	Small and medium enterprise
TAI	Technology achievement index
TCU	Tanzania Commission for Universities
TDTC	Technology Development Transfer Centre
TEA	Tanzania Education Authority
TRIMS	Trade-Related Investment Measures

TRIPS	Trade-Related aspects of Intellectual Property Rights
TZS	Tanzanian Shilling
UDEC	University of Dar es Salaam Entrepreneurship Centre
UDSM	University of Dar es Salaam
URT	United Republic of Tanzania
USD	United States Dollar
USh	Ugandan Shilling
WEF	World Economic Forum
WTO	World Trade Organisation

Executive summary

Higher education policy is becoming increasingly important on national agendas. The widespread recognition that tertiary education[1] is a major driver of economic competitiveness in an increasingly knowledge-driven global economy has made high-quality tertiary education more important than ever in both industrialised and developing countries.

As the Organisation for Economic Co-operation and Development (OECD 2008) has recently pointed out, tertiary education contributes to social and economic development through four major missions:

- The formation of human capital (primarily through teaching).
- The building of knowledge bases (primarily through research and knowledge development).
- The dissemination and use of knowledge (primarily through interactions with knowledge users).
- The maintenance of knowledge (primarily through inter-generational storage and transmission of knowledge).

Tertiary education is also increasingly becoming more diversified and encompassing new types of institutions such as polytechnics, university colleges and technological institutes. Facilities such as these have been created for a number of reasons: to develop a closer relationship between tertiary education and the external world, including greater responsiveness to labour-market needs; to enhance social and geographical access to tertiary education; to provide high-level occupational preparation in a more applied and less theoretical way; and to accommodate the growing diversity of qualifications and expectations of school graduates.

As participation in tertiary education expands in both industrialised and developing countries, tertiary education institutions have assumed responsibility for a far wider range of occupational preparation than in the past. Substantial reforms are thus taking place in tertiary education systems aimed at encouraging institutions to be more responsive to the needs of society and the economy.

For a long time tertiary education has been neglected by the international development community, largely because of the belief that it yields lower social returns relative to other investments – especially primary and secondary education – and therefore should receive fewer public resources. Investments in tertiary education are often considered regressive, perpetuating existing social and economic inequalities.

While there are some concerns as to whether these calculations reflect marginal ('extra' or additional) or average rates of return, there are also more serious conceptual misgivings. Earnings not only reflect additional education, but other characteristics as well (such as innate ability).

While the returns on investment in basic education are visible and almost immediate, the returns to higher education are far more elusive and difficult to measure. A growing body of literature suggests that the conventional estimates of the returns to education do not accurately reflect the social value added by tertiary education, including job creation, good economic and political governance, increased entrepreneurship, and increased inter-generational mobility.

The importance of tertiary education for developing countries extends well beyond the emerging 'knowledge economy'.[2] Its value also lies in its role in building domestic capabilities.

Higher education and economic growth

The contribution of higher education to economic development can also be measured more usefully with the help of a production function or even a simple regression equation. Using the gross enrolment ratio (GER) and higher educational attainment (HEA) as higher education variables, research has shown that both (GER and HEA) can be expected to have a positive effect on the level of economic development (as measured by GDP per capita).

Data from 49 countries of the Asia Pacific region has been used to demonstrate the significant effect of higher education on the economic growth of nations (Tilak 2003). This research has also shown that the larger the stock of the population with higher education (HEA), the higher the prospects for economic growth.

In a rapidly technologically-changing world, technology makes a significant difference to the economic growth of nations. The United Nations Development Programme's (UNDP) work has shown that the level of achievement in technology critically depends upon the level of higher education in a given economy. Most countries with high enrolment ratios in higher education became 'leaders' in technology, with high levels of achievement in technology. The converse is also true: a large number of countries with low enrolment ratios (say less than 10%) are 'marginalised' in the area of technology. Those with a medium level of enrolment ratios – around 20%, like Singapore and Hong Kong – have indeed become 'potential leaders' in technology.

A few countries, like the Philippines and Thailand, with medium and high levels of enrolment ratios are classified as 'dynamic leaders'. The rest who did not sufficiently expand their higher education systems are 'marginalised'. There is not a single country with a low enrolment ratio (less than 10%) in higher education which has achieved a high or medium level of achievement in the technology index (Tilak 2003).

Not all observers however agree that higher education and economic growth are obvious or necessary bedfellows. Prominent studies have reported that the direct and indirect economic impacts of universities on their local communities and regions have often been overestimated. Research in the USA has questioned whether spending more on higher education necessarily provides larger returns for the local economy. Vedder's (2004) work in the USA has found that states with higher spending on colleges and universities often fail to have faster economic growth than states with lower spending, even after controlling for differences in other key variables. This research does not question whether higher education is an important ingredient in promoting economic growth, but does suggest that the returns on public investment in higher education may be limited.

Bloom *et al.* (2005) have challenged the long-held belief in the international development community that tertiary education has little role in promoting economic growth. Their paper reviews evidence about the impact that tertiary education can have on economic growth and poverty reduction in Sub-Saharan Africa where enrolment rates for higher education are by far the lowest in the world, at an average of around 5%.

Bloom and others confirm the findings of Tilak (2003), cited earlier, that one possible channel through which higher education can enhance economic development in poor/developing countries is through technological catch-up. In a knowledge economy, tertiary education can help economies gain ground on more technologically advanced societies as graduates are likely to be more aware of and better able to use new technologies.

Recent evidence suggests that higher education is both a result and a determinant of income, and can produce public and private benefits. Higher education may create greater tax revenue, increase savings and investment, and lead to a more entrepreneurial and civic society. It can also improve a nation's health, contribute to reduced population growth, improve technology, and strengthen governance.

It has been suggested that higher education can lead to economic growth through private and public channels. The private benefits for individuals are well established and include better employment prospects, higher salaries and a greater ability to save and invest. These benefits may result in better health and improved quality of life, thus setting off a virtuous spiral in which life expectancy improvements enable individuals to work more productively over a longer time, further boosting lifetime earnings.

Public benefits are less well recognised, which explains many governments' neglect of tertiary education as a vehicle for public investment. But individual gains can also benefit society as a whole. Higher earnings for well educated individuals raise tax revenues for governments and ease demands on state finances. They also translate into greater consumption, which benefits producers from all educational backgrounds.

In a knowledge economy, tertiary education can help economies keep up or catch up with more technologically advanced societies. Higher education graduates are likely to be more aware of and better able to use technologies. They are also more likely to develop new tools and skills themselves. Their knowledge can also improve skills and understanding of non-graduate co-workers, while the greater confidence and know-how inculcated by advanced schooling may generate entrepreneurship, with positive effects on job creation.

Tertiary education can also have less direct benefits for economies. By producing well-trained teachers, it can enhance the quality of primary and secondary education and give graduates greater opportunities for economic advancement. By training doctors and other health workers, it can improve a society's general health, raising productivity at work. And by nurturing governance and leadership skills, it can provide countries with the talented individuals needed to establish a policy environment favourable to growth. Setting up robust and fair legal and political institutions and making them a part of a country's fabric and developing a culture of job and business creation, for example, call for advanced knowledge and decision-making skills. Addressing environmental problems and improving security against internal and external threats also place a premium on the skills that advanced education is best placed to deliver.

In summary, tertiary education has the potential to improve technological catch-up and, in doing so, maximise Africa's potential to achieve its greatest possible economic growth levels. Investing in tertiary education in Africa may accelerate technological diffusion, which would decrease knowledge gaps and help reduce poverty in the region.

Van Heerden *et al.* (2007) undertook a study to measure the impact of universities on the South African economy. Using a 'general equilibrium' model to simulate various scenarios in the analysis of the impact of higher education in South Africa, this work presents a number of findings relating to income and employment. Three sets of simulations are conducted to determine how strong the secondary or 'knock-on' effects of higher education are on the economy. Each simulation, either directly or indirectly, involves a scenario concerning the higher education sector. First, government expenditure on higher education is hypothetically increased; second, more professionals are trained; and third, the factors of production are assumed to become more productive. Combining the simulations produces a number of positive results with respect to the relationship between higher education and the economy.

According to the World Bank (2008), higher and sustained growth rates in Sub-Saharan Africa require a significant increase in physical and human capital over an extended period. It is argued that there is an urgent need for countries in Sub-Saharan Africa to acquire the capabilities that will spawn new industries that create more productive jobs, multiple linkages and more diversified exports. These capabilities derive from investment in physical assets, such as infrastructure and productive facilities, and in institutions and human capital.

The World Bank (2008) suggests that by raising the level of education and its quality, countries in Sub-Saharan Africa may be able to stimulate innovation, promote the diversification of products and services, and maximise returns from capital assets through more efficient allocation and management. In the face of competition from South and East Asia, a more skills-intensive route to development could provide both resource-rich and resource-poor countries with an avenue for raising domestic value added.

Despite strong enrolment growth most African tertiary institutions are not generating enough graduates and many of them lack the skills needed to support national economic development in the 21st century.

Important factors identified by the World Bank 2008 include:

- The slow growth of public higher education financing.
- The low proportion of science and engineering students.
- The lack of institutional autonomy to make decisions and adapt to changing labour market conditions.
- Inappropriate curricula vis-à-vis the needs of the labour market leading to high levels

of graduate unemployment.
- Poor working conditions and salaries leading to high levels of attrition among academic staff.
- Inadequate and inappropriate technology.
- A reluctance to adopt the 'third mission' – support for the economy.

The World Bank (2008) believes that making tertiary education a driver of growth requires adoption of a number of good practices, especially the following:

- Developing a strategy for national human resource development.
- Granting institutional autonomy coupled with appropriate accountability mechanisms in order to increase opportunities for system differentiation and institutional innovation.
- Reforming financing arrangements to offer incentives for attaining policy goals while providing the stability necessary for institutions to plan strategically.
- Encouraging diversity in teaching and learning approaches that facilitate institutional specialisation.
- Fostering the development of national and regional postgraduate programmes – the best way to increase academic staff numbers and build research capacity.
- Searching for lower-cost delivery alternatives for tertiary education.

Higher education and the knowledge economy

The role of tertiary education in the construction of knowledge economies is crucial. Many developing countries, however, continue to wrestle with challenges relating to: expanding education coverage in a sustainable way; inequalities of access and outcomes; educational quality and relevance; and inflexible governance structures and management practices.

Although research on the impact of the knowledge economy on employment creation and growth is still at a preliminary stage, efforts have begun particularly in advanced economies, to quantify its effects. Comparative studies of job creation in knowledge-based and low-knowledge sectors in the European Union and USA over a ten-year period, found that knowledge-based industries created twice as many new jobs in the USA and four times as many in Europe.

The World Bank (2007) also reported that the nations of North America seem to have benefited quickly from the new opportunities offered, with evidence of a higher growth rate and higher productivity performances over the last 15 years or so. Gaps in income per inhabitant between North America and Europe have increased. In Europe small, dynamic economies such as Finland have become models of knowledge-based growth and competitiveness, while larger continental economies such as France and Germany – which led the technological and industrial race in past decades – have had difficulty adjusting. While Japan has experienced a difficult decade – the 1990s – with slow growth caused by a variety of factors, it has continued to build knowledge economy assets (by increasing spending on basic research, for example) and maintain the competitive edge of its global manufacturing companies. The Republic of Korea, meanwhile, has actively embarked on a knowledge economy track to recover from the financial crisis of 1997/1998.

Among medium- and low-income countries, Chile, Malaysia and Tunisia have clearly taken a knowledge-based approach to increasing competitiveness and growth. World Bank (2007) research on economic growth shows that countries with successful growth – defined as those that both caught up with advanced countries' growth rates and maintained sustained growth over time – did so by combining three important factors: capital accumulation, efficient resource allocation and technological catch-up.

The knowledge economy and economic performance

To monitor its new emphasis on knowledge, the World Bank has created a Knowledge Economy Index (KEI). This benchmarks countries' performance on four aspects of the knowledge economy – the favourability for knowledge development within the economic and institutional regime; education; innovation; and information and communication technologies (ICT). The positive relationship between the results of the KEI and the level of economic development does, however, not establish a causal relationship – a high KEI will not necessarily produce a high level of economic development. On the other hand, it is plausible that high-income countries, because they are more affluent, are able to afford greater investments in knowledge and thus score higher on the KEI.

However, countries that score higher on the KEI do have higher levels of economic development, and vice versa. In fact, econometric tests reveal a statistically significant causal relationship running from the level of knowledge accumulation as measured by the KEI to future economic growth. It is clear that higher KEI values are associated with higher rates of future economic growth, if other factors are held constant. This suggests that higher levels of knowledge in a society do indeed lead to higher levels of economic growth – and consequently to higher levels of economic development. A one-unit improvement in the KEI, equivalent to moving up one decile or 13 positions in the country rankings, leads to an increase of 0.46 percentage point in economic growth, after accounting for initial conditions.

What are the lessons for developing countries? It has been suggested that tertiary-level and research institutions in low-income countries need to focus on creating a pool of experts capable of adopting science and technology and adapting it to the local context. In particular, this means changing the current paradigm to include (in addition to teaching and research) a third mission: service to the community and close cooperation with the public and private sectors to contribute to innovation and development. It is imperative that universities work towards fulfilling their mission of community service – a mission that has been promoted in industrialised countries over the past two to three decades.

Another necessary change in the current academic paradigm is the need to tap into global knowledge by creating regional networks and communities of practice, poles of excellence, and both South-South and North-South partnerships between institutions. Finally, given resource constraints, tertiary-education and research institutions need to undertake managerial and financing reform to reinforce their autonomy and their competitiveness.

In sum, at the tertiary level, policy needs to be pragmatic and flexible to help build a qualified labour force that is able to adapt to changing demand in both local and global markets. This may imply a shift from public financing to public–private partnerships and the implementation of: (a) curricula that include the knowledge and skills required for the new economic context; (b) the new mixed-mode teaching to complement traditional face-to-face teaching; and (c) more open policies towards society and the private sector.

Higher education and regional development

Recent OECD research (OECD 2008) shows that rich countries are putting considerable emphasis on meeting regional development goals, particularly in developing knowledge-based industries. As key sources of knowledge and innovation, higher education institutions are regarded as central to this process.

In the past, neither public policy nor the higher education institutions themselves have tended to focus strategically on the contribution they can make to the development of the regions where they are located. Particularly for older, traditional higher education institutions, the emphasis has often been on serving national goals or on the pursuit of knowledge, with little regard for the surrounding environment.

To be able to play their regional role, the research suggests that higher education institutions must do more than simply educate and research – they must engage with others in their regions, provide opportunities for lifelong learning and contribute to the development of knowledge-intensive jobs which will enable graduates to find local employment and remain in their communities. This has implications for all aspects of these institutions' activities – teaching, research and service to the community and for policy and the regulatory framework in which they operate.

The OECD (2008) report explores the policy measures and institutional reforms that can help higher education institutions live up to this challenge. It considers regional engagement of higher education in several dimensions, notably: **knowledge creation** through research and technology transfer; **knowledge transfer** through education and human resources development; and **cultural and community development**, which can, among other things, create the conditions in which innovation thrives.

The OECD (2008) research shows that examples of higher education helping to serve the needs of local economies can be found in various countries in the past 150 years. However, these links have been sporadic rather than systematic. This has changed dramatically with the recent expansion of higher education, particularly in the non-university sector, which in some cases has consciously aimed to address regional disparities and to widen access. Another important factor changing the context of regional development has been a switch towards more indigenous development, which emphasises the building of skills, entrepreneurialism and innovation within regions. Growing efforts have been made also to remove barriers to the application of research. Policy responses which initially focused on enhancing the capacity for technological innovation through technology transfer and interactions between higher education institutions and private industry have now widened to include public services, social and organisational innovation, and engagement of higher education institutions with the wider social fabric in which they exist.

Universities, innovation and local economies

The relationship between tertiary education institutions, especially universities, and local economic development is a severely under-researched area. An important question in this regard is how tertiary education institutions can contribute to the capabilities of local firms to take up new technologies and market knowledge and to apply it effectively.

The rising interest in the university's economic development role has been fuelled by high-profile examples of successful regional economies in which the university contribution is easily identified – such as Silicon Valley, North Carolina's Research Triangle Park, the Boston area in the USA, and the region around Cambridge in the UK.

The overall economic significance of this model, as well as its promise in particular situations, has often been exaggerated. Part of the problem is the failure to recognise that the best known success stories are atypical. The university origins of enormously successful companies like Cisco, Google and Yahoo (all three of which grew out of Stanford University research and two of which took Stanford licenses) are well known. Less often noted is the fact that new business formation around university science and technology is a very small fraction – probably no more than 2–3% – of the total rate of new business start-ups in the USA.

The same is true of patenting. Even in the USA, where patenting by universities is most common, it is only a minor contributor to the overall stock of patented knowledge. About 3 700 patents were granted to US universities in 2001, out of a total of about 150 000 US patents issued in that year (Mattoon 2006). Moreover, even the most prolific patenting universities are not particularly active by corporate standards.

In 2002, in an effort to develop a broader perspective on the university's role in local economies, an international team of researchers based at the Massachusetts Institute of Technology (MIT) Industrial Performance Center began studying specific cases of industrial transformation in different locations. The overall goal of the Local Innovations System Project (LISP) (Lester 2005) was to examine the role of innovation in the mergence and transformation of local industries. In the first phase of the research, the focus was on the contribution of universities to local industrial development through their participation in local innovation processes.

Research was conducted in 22 locations in six countries (USA, UK, Finland, Norway, Japan and Taiwan). In each case, the focus was on a particular industry or line of business and researchers selected a time period for study which generally ranged between two and three decades. The researchers traced the development of the industry over this period, focusing on the contribution of local innovation processes to the evolution of products, services and production processes.

In reporting their findings (Lester 2005), the researchers note that each of the cases is unique. However, to simplify matters, they produced a typology of industrial transformation processes: indigenous creation; transplantation from elsewhere; diversification into technologically-related industries; and upgrading of existing industries.

For most of the cases, one type of transition clearly dominated. And taken together, the cases strongly suggest that the skills, resources and institutional capabilities associated with each type of transition are different, and that each is associated with a distinct pattern of technology take-up and application. The roles of local universities also appeared to vary considerably depending on which kind of transition was occurring.

In every case, the outcome of the transition hinged on the ability of the firms in the region to identify new technological and market opportunities, and to develop or absorb and then apply new technological and market knowledge. In every case it was the actions of individual firms, motivated by profit, responding to market signals and applying their knowledge of the marketplace, that ultimately determined the outcome. But in every case, too, the innovation performance of these firms depended on more than their own internal capabilities and strategies. It was also affected by the behaviour and performance of local supplier and customer firms, producers of complementary goods and services, and financial intermediaries, as well as local and regional education and training institutions, universities, other public research institutes and foundations, and government agencies and programmes concerned with innovation (both promotional and regulatory). Less tangible attributes of the locale were often also important, such as attitudes towards innovation and entrepreneurship, and the quality of local leadership. All these elements comprise the local innovation system, and the cases make clear that the demands placed on such systems vary depending on what kind of transition is involved.

In cases of new industry creation, a local university or public research laboratory typically played the role of anchor institution; whereas in the case of industry upgrading, the anchor institution was more likely to be a lead firm or a lead customer. In science-based industry formation the highest-impact educational outputs of local universities were PhD-level scientists and engineers with an interest in entrepreneurial careers and some exposure to entrepreneurial business practices. For cases of upgrading, bachelors and masters-level engineering graduates equipped with knowledge of the industry's practices and problems obtained from classes, practical theses, and internships were of greatest value. For science-based industry creation, university technology transfer was active and oriented towards start-ups and small firms. For industry, upgrading these arrangements were more likely to centre on long-term relationships between the university and established firms. In some cases of new industry creation, a local university played a leading role, but none of the upgrading processes were university-led – although in some cases local universities played important supporting roles.

The cases make clear that universities engage with their local communities in many different ways, including:

- Education and training.
- Adding to the stock of codified knowledge (e.g. publications, patents).
- Increasing the local capacity for scientific and technological problem-solving.

- Providing space for open-ended conversations about industry development pathways and new technological and market opportunities.

The most important finding from the four cases is that the university role in local innovation processes depends on which industrial transition pathway is being followed. Although it is common to find many if not most of the activities listed above at any given university, a tendency was observed for certain activities to be most closely associated with particular development pathways.

For Type I transitions involving the creation of a new science-based industry, important activities include providing various kinds of support for new business formation, pro-active technology licensing programmes and policies, and efforts to broker ties between academic researchers and local entrepreneurs. Key individuals at the university may also play important roles in establishing an identity for the new industry, convening conferences and workshops, initiating standard-setting activities, and generally acting as industry 'evangelists' by drawing attention to the existence of local concentrations of related activities and by painting a picture of future impact and growth potential.

For Type II transitions involving the relocation of industries into the region, important university activities include responding to the local human resource needs of the relocating firms, especially by developing new, customised curricula and continuing education programmes. Another important role is to provide technical assistance to local suppliers and sub-contractors.

For Type III transitions involving diversification out of existing local industries into technologically related new ones, a key role for the university is to cultivate technological links between disconnected actors; for example, by establishing on-campus forums for discussion of new applications of local industrial technologies. Another important role is to help build the identity of the new industry locally.

Finally, for Type IV transitions involving the upgrading of the technological base of existing industries, local universities contribute to technical problem-solving through contract research and staff consulting, developing industry-relevant degree and continuing education programmes, creating internship and staff leave opportunities in the local industry, convening foresight exercises and user-supplier forums on campus to discuss the future development of the industry, and participating in global best-practice scanning activities with local industrial practitioners.

These findings cast doubt on the usefulness of the one-size-fits-all approach to economic development that so many universities have been pursuing, with its focus on patenting, licensing, and startups. They instead suggest the need for a broader, more differentiated view of the university role.

The conclusion of the MIT study is that local economies thrive to the degree that local firms succeed in adapting to new market and technological opportunities through innovation in products, services, and production processes. This innovation performance hinges in turn on the ability of local firms either to develop new technological and market knowledge themselves or to acquire it from elsewhere and then apply it productively. This study sheds considerable light on how universities can strengthen these local innovative capabilities:

1. **Universities have multiple ways to contribute to local innovation processes directly.** The possibilities are not limited to patenting and licensing discoveries made in university laboratories. In addition to their own discoveries, universities can help to attract new knowledge resources from elsewhere. They can help to: (a) adapt knowledge originating elsewhere to local conditions; (b) integrate previously separate areas of technological activity in the region; and (c) unlock and redirect knowledge that is already present in the region but not being put to productive use.
2. **In most cases, the indirect support provided by universities for local innovation processes is likely to be more important than their direct contributions to local industry problem-solving.** The most important of these indirect contributions is education. But a university can also play an important role as a public space for ongoing conversations involving local industry practitioners about the future direction of technologies, markets and local industrial development. This public space can take many forms, including meetings, conferences, industrial liaison programmes, standard forums, entrepreneur/investor forums, visiting committee discussions of departmental curricula, and so on. The conversations between university and industry people that occur in these spaces are rarely about solving specific technical or commercial problems. But they often generate ideas that later become the focus of problem-solving both in industry and in universities. The importance of the public space role of the university and its contribution to local innovation performance is frequently underestimated.
3. **The conditions, practices, and attitudes that lead to successful technology take-up and application in local industries depend on the specific characteristics of the industry and its development pathway**. These studies make clear that industry upgrading, industry diversification, industry importation and industry creation are each associated with different local patterns of technology take-up and application. More specifically, for each type of transition a distinct pattern of university participation was observed in the local innovation system.
4. **Universities should approach their role in local innovation processes strategically.** This means developing an understanding of the particular circumstances and needs of local industries and the strengths and weaknesses of their own institutions, and it means seeking a fit between local industry needs and internal university capabilities. Universities should discard the one-size-fits-all approach to technology transfer in favour of a more comprehensive, more differentiated view of the university's role in local economic development.
5. **A strategic approach to the local economic development role is compatible with the pursuit of excellence in the university's traditional primary missions in education and research.** In fact, success in these primary missions is a necessary condition for contributing effectively to innovation and growth in the local economy. The fear that these missions will somehow be harmed is not a good reason for universities not to embrace their role in local innovation processes.

One of the key findings of this project is that no single strategy of university engagement is the panacea for aiding economic growth everywhere. What works is largely determined by the type of industrial transformation that is being attempted. For example, in the case of the creation of a new industry, the key activities support various aspects of new business transformation. The university is often a broker between the university's researchers and local entrepreneurs. In the case of transplanted industries, a key university function is producing human resources for the firm and often creating a curriculum and a continuing education programme that supports the firm's growth. For cases involving the diversification of existing firms, the university can often serve to link firms together, allowing them to consider how the technology might be applied to their businesses. When local firms are attempting to upgrade their technology base, universities can often serve as problem-solvers, offering consulting and contract research opportunities.

University–industry linkages

The comparative advantage of certain universities to complement teaching with research is behind the gathering interest in university–industry linkages (UILs) as a vehicle for supporting (if not accelerating) technology development. Virtually every industrial country is moving to make university-industry links a centrepiece of its innovation systems, and the notion of a 'triple helix' – representing the symbiotic relations linking government, universities and the business community – has acquired wide currency.

Also important is the speed with which industrialising countries (such as China and India, which are constructing innovation systems) have embraced technology as the key to development and with it the use of research-oriented universities as a means of augmenting the innovation capability of the economy.

Research suggests that there are four principal players in the challenge to ensure that universities can be drivers of growth: national government, sub-national governments, firms and universities.

Universities are being viewed as central to the nurturing of technology in all countries that are serious about strengthening their national innovation systems. Ultimately, most of the technological advances that have economic consequences can be traced indirectly or directly to universities, either through the training provided, the knowledge spill-overs, the actual research conducted or through UILs that enabled firms and faculty members to collaborate in the development of technologies.

Even in Japan and the USA, however, the output of technologies from universities as measured by patents is relatively small, although universities account for the majority of papers published in refereed scientific journals. The case is the same in European countries, and to some it suggests the potential for more technology development by universities. Others claim that the division of labour, whereby universities educate students and university-based researchers add to the storehouse of knowledge through their publications, is a good one. It keeps the focus on teaching, and basic research largely complements applied research. According to this philosophy, practised by leading universities such as Johns Hopkins, by being drawn into the crafting of commercialisable technologies and into links with the business sector, the university is likely to see its primary role diluted, and the quality of its education could suffer. Those arguing on such lines can also point to the great advances in technology during recent decades, which suggest that no fundamental change in the role of universities is called for.

But the consensual view that times have changed is gaining ground. With the USA and a few European countries in the lead, national governments have begun applying with greater force a number of policies to promote research in universities and to encourage UILs. In East Asia, the governments of Japan, China and Singapore are also broadening and intensifying their efforts.

The push toward research and its commercialisation in the USA, Europe, Japan and China has acquired greater force because governments are trimming their contributions to university budgets and requiring them to supplement their earnings from the fruits of their research – whether through knowledge transfer, spin-offs or equity stakes in start-ups. By supporting competition between public and private universities, the state has also increased the pressure on once-protected state universities, as in Japan and Singapore, to bid for students and faculty on the basis of their reputations not only as teaching institutions but also as centres of research. This strategy complements pressures arising from globalisation. In the process, public universities are gaining more autonomy, which private universities have always enjoyed. This freedom opens opportunities for a more aggressive pursuit of reforms to attract better students, to expand research and development (R&D), to explore new sources of financing, and to acquire entrepreneurship skills. For universities, most of which have no tradition of entrepreneurship and limited managerial capacity, these additional responsibilities entail learning corporate skills, providing new incentives and introducing new courses.

The state has also moved in a number of countries – starting with the USA – to make the development and patenting of technologies, as well as the licensing of their use, attractive for university researchers and universities, by granting researchers the intellectual property rights over scientific findings arrived at with the use of public funds.

National governments can further influence the commercial orientation of universities by developing science parks in the vicinity of universities, often with the participation of local developers, and by spurring university spin-offs and start-ups with university connections directly through their policies on venture capital and more indirectly through their rules governing capital markets and the launching of initial public offerings.

As firms have moved to moderate their own basic research and focus their own efforts, they have come to rely more on university-based researchers in emerging fields where interdisciplinary expertise is required, such as nanotechnology. National governments, as in China, are also attempting to multiply UILs by measuring the performance of universities with reference to the number of spin-offs or start-ups, among other indicators. Where this strategy works, many of the emerging firms are likely to maintain their links with the university, particularly in fields such as biotechnology that are more dependent on advances in basic science and on tacit scientific knowledge.

In many countries, the policies of the central government with respect to UILs are complemented by those of the sub-national authorities, whether provincial, county or municipal. In Brazil, Canada, China and the USA, for example, this decentralisation sets the stage for competition to attract and retain industries, especially those that generate numerous localised links, employment, exports and added value. Frequently the favoured industries are technological and skills-intensive. For them, a research-oriented university with strong science and professional programmes can be a major attraction because it can be a source of both trained staff members and of knowledge spill-over. Researchers in the university can, for instance, assist with the refinement of existing technologies and the development of new techniques.

The decision to establish links ultimately does however ultimately rest with the firms themselves. The recent experience of industrial countries regarding the interaction between firms and universities is quite mixed, with no clear trends apparent.

Firms are more aware of the gains in competitiveness from innovation and are sensitive to the high returns from R&D. However, much of the R&D outlay is by large companies. Smaller companies invest little in research, although they do spend on testing, quality control and incremental innovation – whether done in-house, together with suppliers, or (more often) outsourced to research labs and consultants. The larger firms have begun narrowing their own research efforts and making greater use of alliances and collaborative arrangements, taking over firms that have introduced new technologies, using outsourcing arrangements, and instituting UILs. Thus, in the interests of reducing costs, tapping a wider range of disciplines, canvassing a variety of technological options, and spurring multiple competing research initiatives, firms are moving towards open innovation practices. Relative to those in the UK and USA, firms place more emphasis on an open innovation approach. One result of this emphasis that coincides with the efforts made by universities themselves is some increase in links between firms and university faculties.

In Japan, companies prefer informal ties with universities. Corporate researchers co-author papers with university faculty members, spend time working at university laboratories, do joint projects with university researchers, and enter into consulting arrangements with university-based researchers. Typically, the UILs are with the leading large universities and research centres; firms are ready to seek out the best academic talent from across the country rather than limiting themselves to universities close to their own headquarters or research facilities.

At the other extreme is the USA, where UILs cover the entire spectrum but formal contractual arrangements with universities are common, as are outsourcing of entire research projects to university laboratories, joint research agreements and individual contracts with key researchers. Europe falls somewhere in the middle. In the Republic of Korea and India, small firms have virtually no contact with universities as far as research is concerned, but they may seek help for the purpose of trouble-shooting from individual researchers. In those countries, links, mostly of a localised nature, are emerging between some of the larger companies in the technology sectors and elite universities. A similar tendency is materialising in China as a result of a determined push by governments to induce both universities and state enterprises to cooperate in developing technologies.

Southern Africa

Little was known about the nature and scale of interaction between universities in southern Africa and private firms until a recent study (Kruss & Petersen 2008) of southern African universities. This study shows, for example, that 58% of Southern African Development Community's (SADC) public higher education institutions can provide examples of collaborative community development programmes, 41% examples of collaborative projects with business and industry, while 59% of them have plans in place for collaboration with industry.

There are not many forms of university-firm interaction, but two relatively commonplace instances include the education of work-ready students and consultancy. Two potentially critical areas of interaction – software development and agricultural services – were ranked much lower in importance (Kruss & Petersen 2008).

In terms of innovation, the picture is not encouraging, with 60% of the sample reporting no involvement with technology transfer; 40% not being involved with research and development for firm innovation, and 52% not being involved in software development or design (Kruss & Petersen 2008).

According to the Kruss and Petersen (2008) study, channels of interaction with firms that SADC universities rate as very or moderately important include: public conferences and meetings, recent graduates hired by firms, publications and reports in the public domain, individual consultancy, research and development cooperative projects, and informal information exchange. Channels regarded as less important are those related to the new commercialisation role of universities in the developed world – patents, technology incubators, spin-off firms, licensed technology, and science/technology parks.

For South Africa, various forms of university-firm interaction have been identified. The traditional forms of interaction include donations and student sponsorship. However, the dominant forms of interaction are consultancies and contracts. In addition, there is small but increasing evidence of new entrepreneurial forms of interaction, such as commercialisation, in which higher education researchers attempt to commercialise intellectual work in the form of spin-off companies or in collaboration with an existing company (Kruss & Petersen 2008).

Universities and Public Research Institutions (PRIs) as Drivers of Economic Development – the East Asian Experience

From 1950 to 2000, the East Asian economies fashioned a uniquely successful industrial development model in which the focus was clearly on 'science and technology as the primary productive forces' (Mathews & Hu 2007). The idea was that these economies, as latecomers, could focus their industrial development on targeted catch-up efforts, industry by industry and technology by technology, drawing on the knowledge accumulated in the leading countries. The model was developed first in Japan, then rapidly adopted in Korea and Taiwan (China), and later taken up by Singapore and to some extent elsewhere in South-East Asia.

Latecomer firms, like latecomer nations, exploit their late arrival to tap into advanced technologies, rather than replicating the entire preceding trajectory. They can accelerate their uptake and learning efforts through collaborative processes and the help of state agencies, thereby avoiding some of the organisational inertia that holds back their more established competitors. They thus develop strategy on the basis of the possibilities inherent in their latecomer status. The strategic goal of the latecomer is clear: catch up with the advanced firms and move as quickly as possible from imitation to innovation. This strategy has never been put into practice more effectively than by the East Asian economies in their half-century of accelerated development.

Universities played a very special role in East Asian development – not as drivers of innovation, as commonly viewed in the West, but as shapers of human capital formation. During the second half of the 20th century, universities were at the forefront in training generations of highly skilled, technologically sophisticated graduates who could be employed successfully by domestic firms seeking to enter global industries, by multinational corporations, and not least by the institutions steering the economy's industrial development. The foundation for this role played by the universities and newly established polytechnics was the steadily rising rate of adult literacy and numeracy.

In contrast, the PRIs, such as the Industrial Technology Research Institute (ITRI) in Taiwan (China) and the South Korean Development Institute, played the role of technology capture agencies and technology diffusion managers, going abroad to seek the technologies needed by local firms and building capabilities in those technologies, which the PRIs passed across to the private sector as rapidly as possible. These institutes worked closely with domestic firms (in some cases even establishing firms where they were lacking), catalysing their capacities to become technologically sophisticated players in their own right. PRIs drove the development of national innovative capacity in East Asian economies as they gradually moved from catching up and imitation to fast-follower innovation.

In the early years of the 21st century, both universities and PRIs in East Asia are undergoing further transformation. Thus, economies as diverse as Hong Kong (China), Singapore and Taiwan (China) are pursuing similar strategies: universities and PRIs are encouraged to keep abreast of new technologies by patenting, publishing in scientific journals, and promoting spin-off enterprises. Although the results are still rudimentary at this stage, they point to a trend that could become significant in the near future, particularly as it is adopted and expanded in China and India.

Of all the countries in the developing world today, China and, to some extent, India, appear to be the most successful at applying the lessons of technology leverage. They are drawing on the accumulated stock of knowledge of the industrial world and applying it in accelerated fashion to their development agendas. China, in particular, appears to have studied the model of Taiwan (China) very closely and, despite political differences, is applying it very successfully to its own case.

Chapter 1
Introduction

Higher education policy is becoming increasingly important on national agendas. The widespread recognition that tertiary education is a major driver of economic competitiveness in an increasingly knowledge-driven global economy has made high quality tertiary education[1] more important than ever before in both industrialised and developing countries.

As the OECD recently pointed out, tertiary education contributes to social and economic development through four major missions:

- The formation of human capital (primarily through teaching).
- The building of knowledge bases (primarily through research and knowledge development).
- The dissemination and use of knowledge (primarily through interactions with knowledge users).
- The maintenance of knowledge (inter-generational storage and transmission of knowledge) (OECD 2008).

The same OECD research points to the changing nature of tertiary education. For most of the 20th century, tertiary education was what happened in universities. This largely covered teaching and learning which required high-level conceptual and intellectual skills in the humanities, sciences and social sciences; the preparation of students for entry to a limited number of professions such as medicine, engineering and law; and advanced research and scholarship. Tertiary education is, however, becoming much more diversified and today encompasses new types of institutions such as polytechnics, university colleges and technological institutes. These have been created for a number of reasons: to develop a closer relationship between tertiary education and the external world, including greater responsiveness to labour market needs; to enhance social and geographical access to tertiary education; to provide high-level occupational preparation in a more applied and less theoretical way; and to accommodate the growing diversity of qualifications and expectations of school graduates (OECD 2008).

As participation in tertiary education expands in both industrialised and developing countries, tertiary education institutions are assuming responsibility for a far wider range of occupational preparation than in the past. As the result of a combination of the increased knowledge base of many occupations and individuals' aspirations, today not only doctors, engineers and lawyers, but also nurses, accountants, computer programmers, teachers, pharmacists, speech therapists and business managers receive their principal occupational qualifications from a tertiary education institution. Furthermore, tertiary education institutions are now involved in a wider range of teaching than their traditional degree-level courses. While the extent of such teaching is not large, many examples can be found of tertiary education institutions that offer adult education and leisure courses, upper secondary courses to prepare students for tertiary-level study, and short specific occupational preparation at sub-degree level. In addition, it has become more common for tertiary education institutions not only to engage in teaching and research, but also to provide consultancy services to industry and government and to contribute to national and regional economic and social development (OECD 2008).

In addition, substantial reforms are taking place in tertiary education systems mainly aimed at encouraging institutions to be more responsive to the needs of society and the economy. This has involved a reappraisal of the purposes of tertiary education and the setting by governments of new strategies for the future. It has also resulted in more room for institutions to manoeuvre, but with clearer accountability for institutions to society.

This recognition of the importance of higher education is a recent development. While higher education was in vogue in the 1950s and 1960s, it subsequently fell out of favour. The various development paradigms of the mid-20th century had little place for higher education. Even when human capital began to garner attention in the 1990s, the focus was on those aspects that directly affected the human capital of the poor, namely primary education and health (Kapur & Crowley 2008).

It was not helpful also that the role of higher education, in both theoretical and policy terms, lacked adequate empirical knowledge of what was happening *within* universities and to the students who spend a considerable part of their prime years in these institutions. While it is clear that there has been substantial growth in higher education, whether measured by the number of students or amounts spent, it is unclear just how meaningful this large growth is. Researchers have found it exceedingly difficult to get a good grip on two critical output measures: how to measure quality in higher education and how to determine the value added by higher education over and beyond the student's innate abilities (Kapur & Crowley 2008). As Kapur and Crowley show, it is entirely possible that even in systems which are of good quality, the credentialing aspects of higher education benefit the few who have access to it and crowd out from labour markets others with similar ability but who lack access – the more prevalent formal qualifications, the more pressure to educate oneself. In other words, the upward spiral in education credentialing may not yield social benefits commensurate to expenditure.

Why higher education?

Tertiary education has long been neglected by the international development community because of the belief that it yields lower social returns relative to other investments, especially primary and secondary education, and should therefore receive fewer public resources (Schultz 1998). Investments in tertiary education are often considered regressive, reproducing existing social and economic inequalities. A 1986 World Bank study estimated that social rates of return for higher education in developing countries were on average 13% lower than the returns from basic education (Psacharopoulos *et al.* 1986). A more recent review of 98 countries for the period 1960–1997 found that the typical estimate of the rate of return from primary schooling was 18.9%, while for tertiary education the return was 10.8% (Psacharopoulos & Patrinos 2002).

While there are some concerns as to whether these calculations reflect marginal ('extra' or additional) or average rates of return, there are also more serious conceptual misgivings. Earnings reflect not only additional education but also other characteristics (e.g. innate ability). Wages may not reflect marginal product, given the degree to which they depend on a host of institutional factors and the nature and structure of labour markets. While the returns on investment in basic education are visible and nearly immediate, the returns to higher education are far more elusive and difficult to measure. Re-evaluations of data suggest that standard estimates of social returns to tertiary education do not accurately reflect the positive public externalities, as they are based on the private returns measured by wage differentials and the social costs associated with education (Birdsall 1996). A growing body of literature suggests that the conventional estimates of the returns to education do not accurately reflect the social value added by tertiary education, including job creation, good economic and political governance, increased entrepreneurship, and increased intergenerational mobility (Bloom *et al.* 2006).

In the context of development, the economic benefits of universities naturally receive the most attention. These range from their role in developing a country's skills base to their role in creating 'codifiable public knowledge', such as publications, journals, books, patents, and prototypes. In recent years, the benefits of more direct university-industry partnerships, including contract research, cooperative research, technology licensing, faculty consulting, and access to specialised equipment and incubation services, have been noted. Universities also provide the public space necessary to facilitate the exchange of tacit knowledge and resources between industries and institutions, through various methods such as meetings and conferences, research centres and mentoring programmes, alumni networks, personnel exchanges, and visiting committees (Lester 2006).

A broader (than purely economic) rationale for higher education has also been recognised in developing countries. Many leaders of these countries have been educated abroad and are aware of the socialisation effects of higher education producing new nationalist elites (Kapur & Crowley 2008). They also recognise that technological weaknesses have contributed to colonisation in the first place and that building higher education institutions is important to fostering the technological capabilities that would hedge against history repeating itself. Higher education has therefore been considered essential for developing the capabilities for 'self-reliance'. Since most newly independent developing countries are largely agrarian, nowhere has the need for domestic technical capabilities been more apparent than in agriculture.

Economic historians have long recognised that increasing agricultural productivity is vital to improve living standards in almost any poor country. As Kapur and Crowley (2008) explain, an important reason why the Green Revolution was far more successful in Asia than in Africa was the greater domestic technological capabilities in the former, developed through local agricultural universities and research centres that could adapt the new Green Revolution technologies (developed by the system of international agriculture research centres) to local conditions. Thus, in the absence of domestic skills, even global public goods (embodied in this case in the Green Revolution technologies) have very limited payoffs. Today, poor developing countries face even worse odds (Kapur & Crowley 2008).

Kapur and Crowley (2008) further point out in great detail that in the past, investment in agricultural research in rich countries had considerable technological spill-over effects. However, for several reasons, these spill-overs are in decline. First, the types of technologies being developed in rich countries are less appropriate to developing-country agriculture because of a shift in research priorities. With the research focus in rich countries shifting from yield improvements in major crops to other agricultural and non-agricultural concerns like crop appearance and environmental effects, its relevance to the needs of poor countries declines. Second, applicable technologies developed in richer countries may not be as readily accessible because of intellectual property protection of privately owned technologies: many biotech companies have little or no interest in developing technologies for applications in less-developed countries; and even where they have such technologies available, they are often not interested in pursuing potential markets in less-developed countries. Third, technologies that are applicable and available are likely to require more substantial local development and adaptation than in the past to tailor the more advanced skills to local production environments. Consequently, developing countries will have to extend their own R&D efforts upstream to more fundamental areas of science and hence will need to develop greater domestic, agricultural research human capital (Pardey *et al.* 2006). Thus the importance of tertiary education for developing countries extends well beyond the emerging 'knowledge economy'. Its value also lies in its role in building domestic capabilities.

Chapter 2 of this review examines the relationship between higher education and economic growth. In the last few years, the debate on higher education has begun to shift with the development of the 'knowledge economy'. Chapter 3 examines the implications of this development for higher education. Chapter 4 assesses the relationship between higher education and regional development, including the role of universities in innovation and local economic development. The latter assessment is based on an analysis of the Local Systems Innovation Project of the Massachusetts Institute of Technology (MIT). Chapter 5 expands on this theme through further analysis of the role of government, firms and universities in stimulating economic development. Finally, Chapter 6 looks at the role of universities and public research institutions as drivers of economic development with specific reference to the East Asian experience.

Chapter 2
Higher education and economic growth

Higher education is an important form of investment in human capital development. In fact, it can be regarded as a high level or a specialised form of human capital, the contribution of which to economic growth is very significant. It is rightly regarded as the 'engine of development in the new world economy' (Castells 1994:15).

In the present context of transformation of nations into knowledge economies and knowledge societies, higher education provides not just educated workers, but knowledge workers to the growth of the economy. It creates attitudes, and makes possible attitudinal changes necessary for the socialisation of individuals and the modernisation and overall transformation of societies. Probably most importantly, higher education assists, through teaching and research, in the creation, absorption and dissemination of knowledge.

What is the effect of higher education on economic growth? There is a general presumption that higher education is not necessary for economic growth and development, particularly in developing countries. On the other hand, it is argued that it is literacy and primary education that are important. As described earlier, estimates of the rate of return have contributed to the strengthening of such a presumption.

Conventionally the contribution of education to economic development is analysed in terms of education-earnings relationships and, more conveniently, in the form of rates of return. Rates of return are a summary statistic of the relationship between lifetime earnings and the costs of education. Again, as pointed out briefly earlier, available estimates on rates of return show that the social rates of return to investment in primary education are the highest, followed by secondary education. According to this type of analysis, the returns to higher education are the least. The pattern is more or less true in general with respect to private rates of return also. Such evidence is extensively used to discourage public investment in higher education and to concentrate rather exclusively on primary education. Though the rate of return to higher education is less than that of primary education, it should nevertheless be noted that higher education does yield an attractive rate of return to the society (above 10%) and to the individual as well (19%) (Psacharopoulos & Patrinos 2002).

Table 1 reflects regional average rate of return estimates. There are wide variations in the rates of return between several countries, but on the whole they show that: (a) investment in higher education yields positive rates of return to the individual and also to the society at large; (b) in several countries social rates of return are high – above 10%, which can be considered an acceptable alternative rate of return; and (c) rates of return seem to be increasing over the years in some countries. Generally, declining rates of return over time are often expected; but this is not necessarily the case in all countries. For example, in some Asian countries, the rate of return is increasing. This may be due to the rapid increase in the demand for more educated personnel.

Table 1: Returns to higher education

Region	Social (%)	Private (%)
Asia*	11.0	18.2
Europe/Middle East/North Africa*	9.9	18.8
Latin America/Caribbean	12.3	19.5
OECD	8.5	11.6
Sub-Saharan Africa	11.3	27.8
World average	10.3	19.0

* Non-OECD
Source: Psacharopoulos & Patrinos (2002)

The contribution of higher education to economic development can also be measured more usefully with the help of a production function or even a simple regression equation. Using the gross enrolment ratio and higher educational attainment as higher education variables, Tilak (2003) has shown that both can expect to have a positive effect on the level of economic development (as measured by GDP per capita). Using data on 49 countries of the Asia Pacific region, GDP per capita in 1999 was regressed on enrolment ratio around 1990. A time lag was allowed in the production function to yield meaningful results.

Tilak (2003) found that the regression coefficient was positive and statistically significant at the 1% level, indicating a significant effect of higher education on economic growth of nations. Tilak (2003) has shown also that the stock of the adult population with higher levels of education is an important indicator of the level of development of higher education. This 'stock' indicator (as opposed to gross enrolment ratio, a 'flow' indicator) represents the cumulative efforts of a country in the development of higher education over the years. This attribute is also expected to have a stronger effect on development, as the population group considered here forms a part of the labour force (and indeed forms an important and even a large part of the skilled and educated labour force). The larger the stock of the population with higher education, the higher the potential for economic growth. In the regression estimates, as expected, this gives a better result, with a higher coefficient of determination, and the variable has a higher effect, as the value of the coefficient suggests.

Both gross enrolment ratio and higher levels of education make it clear that higher education makes a significant and positive contribution to economic growth. However, it may be argued that simple regression equations of economic development on education suggest only a correlation between the two, and not necessarily a cause and effect relationship. Such an argument is partly pre-empted by Tilak, by allowing a time lag for higher education to *cause* economic development. Also, there are very few countries with higher levels of higher education being economically underdeveloped, while all the economically rich countries have not necessarily advanced in the development and spread of higher education.

Higher education and technological absorption

In a rapidly technologically-changing world, technology makes a significant difference to the economic growth of nations. UNDP (2001) developed a technology achievement index (TAI), based on the degree of creation of technology in a given economy, the extent of diffusion of old and recent innovations, and human skills. It is clear from this body of work that the level of achievement in technology critically depends upon the level of higher education in a given economy. This is so because it is higher education and research that help in developing new technology; and it is higher education and research that contribute to innovations and their diffusion. One can therefore expect a very strong effect of higher education on the development of technology in any society. In fact, the level of achievement in technology may be a close indicator of economic growth itself. Most countries with high enrolment ratios in higher education became 'leaders' in technology, with high levels of achievement in technology, as shown in Table 2. The converse is also true: a large number of countries with low enrolment ratios (say less than 20%) are 'marginalised' in the area of technology. Those with medium level of enrolment ratios (nearly 10%, like Singapore and Hong Kong) have indeed become 'potential leaders' in technology (Table 2).

Table 2: Higher education (GER) and Technology (TAI)

Gross enrolment ratio (GER)	High TAI (>0.5)	Medium TAI (0.4–0.5)	Low TAI (<0.4)
High (>20)	New Zealand, Korea, Australia, Israel, Japan		Philippines
Medium (11–20)	Singapore	Hong Kong	Thailand, Cyprus, Syria
Low (<10)			Iran, Indonesia, Malaysia, India, Sri Lanka, Nepal, China, Pakistan

Source: UNDP (2001); UNESCO (1999)

A few countries with medium and high levels of enrolment ratios, like the Philippines and Thailand, are classified by the UNDP (2001) as 'dynamic leaders'. The rest who did not expand their higher education systems adequately, are indeed 'marginalised'. There is not a single country with a low enrolment ratio (less than 10%) in higher education which has achieved high or medium level of achievement in the technology index.

The relationship between higher education and technology could be shown statistically as well. The simple coefficient of correlation between the enrolment ratio in higher education and TAI in the Asia and the Pacific countries is as high as 0.8, and that between technology and higher education attainment is 0.65. Though the number of observations is small, the simple regression equations estimated here show a very strong and statistically significant effect of higher education on the level of achievement of technology.

Questions about the relationship between higher education and economic growth

It has been suggested by many observers that the role of higher education in a knowledge-driven economy has never been more crucial as innovation and human capital are seen as keys to future economic growth.

However, not all observers agree that higher education and economic growth are obvious or necessary bedfellows. Prominent studies have reported that the direct and indirect economic impacts of universities on their local communities and regions have often been overestimated (see studies cited below). Moreover, work by Vedder (2004) has questioned whether spending more on higher education necessarily provides larger returns for the local economy. Vedder's work in the USA has found that states with higher spending on colleges and universities often fail to have faster economic growth than states with lower spending, even after controlling for differences in other key variables. While Vedder does not question whether higher education is an important ingredient in promoting economic growth, he does suggest that the returns to public investment in higher education may be limited.

As pointed out earlier, some of this controversy comes about because of the difficulty of measuring the exact contribution of colleges and universities to economic growth. Standard economic base analysis can do a good job of accounting for the payroll, spending, and employment contributions of a university to a community, but relies on estimates of economic multipliers to determine the secondary benefits of university activities. Studies have produced a range of multipliers (ranging from 1 to 3) and estimates of economic benefits are highly sensitive to the choice of multiplier. Perhaps most problematic is that these studies cannot provide any estimate of whether this is the best use of economic assets for a given region. If the university were not in the community, the same land and resources would undoubtedly have been used for some other activity and may have produced a similar or higher level of economic growth. Other studies focus on the influence of universities' outputs on human capital and technology. These studies examine the role of higher wages received by college graduates in the local economy, as reflected in higher tax revenues, consumer spending, and personal savings. Of course, for college towns to capture such benefits, graduates need to stay in the communities where they were educated.

Universities and other higher education institutions are frequently asked to justify, in economic terms, the allocation of state funds toward their programmes. These institutions often respond by conducting economic impact studies. The traditional approach to economic impact studies views increases in expenditure by a university as a means to increase new jobs and to expand a region's economic base. Recent studies have employed a new approach that also accounts for increases in a region's skills base as part of the economic impact. Although the skills-base approach yields favorable results for higher education, recent applications of the technique fail to consider fully the effects of migration on a university's economic impact and, thus, substantially overestimate the impact.

The majority of studies also employ an economic-base approach, which treats the increase or decrease in expenditures by a university as analogous to the expansion or withdrawal of an industry from a region. Bluestone (1993) revised the traditional economic-base approach. He argued that the scope of an economic impact analysis should be expanded to include additions to the skills base of the region in which the institution is located, given that, through higher education, a university produces skilled workers who earn higher incomes than they would without that education. This skills-base approach yields substantially higher estimates than the economic-base approach. Since universities use this approach in institution-based research and decision-makers utilise their results, it is important to consider the validity of this method to estimate economic impact.

Brown and Heaney (1997) argue that the skills-base approach substantially overestimates the economic impact of a university. The overestimation arises from an incomplete consideration of the potential effects migration has on human resource location. They argue that the ultimate source of economic impact is expansion of the economic base from the creation of new and higher paying jobs.

Siegfried *et al.* (2007) describe methodological approaches and pitfalls common to studies of the economic impact of colleges and universities. Such studies often claim local benefits that imply annualised rates of return on local investment exceeding 100%. The authors address problems in these studies pertaining to the specification of the counterfactual, the definition of the local area, the identification of 'new' expenditures, the tendency to double-count economic impacts, the role of local taxes, and the omission of local spill-over benefits from enhanced human capital created by higher education, and offer several suggestions for improvement. The authors suggest that if these economic impact studies were conducted at the level of accuracy most institutions require of faculty research, their claims of local economic benefits would not be so preposterous, and, as a result, trust in and respect for higher education officials would be enhanced.

Bloom *et al.* (2005) challenge the long-held belief in the international development community that tertiary education has little role in promoting economic growth. Their paper reviews evidence about the impact that tertiary education can have on economic growth and poverty reduction in Sub-Saharan Africa, where enrolment rates for higher education are by far the lowest in the world at around an average of 5%. They suggest that because of a longstanding belief that primary and secondary schooling are more important than tertiary education for economic development, the international development community has encouraged African governments' neglect of higher education. For example, from 1985 to 1989, 17% of the World Bank's worldwide education-sector spending was on higher education. But from 1995 to 1999, the proportion allotted to higher education declined to just 7%. Higher education in Africa has suffered from such reductions in spending, with many countries struggling to maintain even low enrolment levels. Furthermore, the academic research output in the region is among the world's lowest.

Bloom *et al.* (2005) confirm the findings of Tilak (2003) that one possible channel through which higher education can enhance economic development in poor/developing countries is through technological catch-up. In a knowledge economy, tertiary education can help economies gain ground on more technologically advanced societies, as graduates are likely to be more aware of and better able to use new technologies.

The analysis here supports the idea that expanding tertiary education may promote faster technological catch-up and improve a country's ability to maximise its economic output. Investing in tertiary education in Africa may accelerate technological diffusion, which would decrease knowledge gaps and help reduce poverty in the region.

According to Bloom *et al.* (2005), recent evidence suggests that higher education is both a result and a determinant of income, and can produce public and private benefits. Higher education may create greater tax revenue, increase savings and investment, and lead to a more entrepreneurial and civic society. It can also improve a nation's health, contribute to reduced population growth, improve technology and strengthen governance.

Bloom *et al.* (2005) further demonstrate that higher education can lead to economic growth through private and public channels. The private benefits for individuals are well established, and include better employment prospects, higher salaries, and a greater ability to save and invest. These benefits may result in better health and improved quality of life, thus setting off a virtuous spiral in which life expectancy improvements enable individuals to work more productively over a longer time, further boosting lifetime earnings.

Public benefits are less well recognised, which explains many governments' neglect of tertiary education as a vehicle for public investment. But individual gains can also benefit society as a whole. Higher earnings for well-educated individuals raise tax revenues for governments and ease demands on state finances. They also translate into greater consumption, which benefits producers from all educational backgrounds.

In a knowledge economy, tertiary education can help economies keep up or catch up with more technologically advanced societies. Higher education graduates are likely to be more aware of and better able to use technologies. They are also more likely to develop new tools and skills themselves. Their knowledge can also improve skills and understanding of non-graduate co-workers, while the greater confidence and know-how inculcated by advanced schooling may generate entrepreneurship, with positive effects on job creation.

Tertiary education can also have less direct benefits for economies. By producing well-trained teachers, it can enhance the quality of primary and secondary education and give graduates greater opportunities for economic advancement. By training doctors and other health workers, it can improve a society's health, raising productivity at work. And by nurturing governance and leadership skills, it can provide countries with the talented individuals needed to establish a policy environment favourable to growth. Setting up robust and fair legal and political institutions and making them a part of a country's fabric, and developing a culture of job and business creation, for example, call for advanced knowledge and decision-making skills. Addressing environmental problems and improving security against internal and external threats also place a premium on the skills that advanced education is best placed to deliver (Bloom *et al.* 2005).

The critique by Bloom *et al.* (2005) of traditional rate of return analysis is impressive. They state that traditional rate of return analysis focuses solely on the financial rewards accrued by individuals and the tax revenues they generate. It neglects the broader benefits of advanced education manifested through entrepreneurship, job creation, good economic and political governance, and the effect of a highly educated cadre of workers on a nation's health and social fabric.

Bloom *et al.* (2005) go on to cite a number of studies which reflect increasingly the importance of higher education for growth.

- In a cross-sectional study, Barro and Sala-i-Martin (1995) found that male educational attainment, particularly secondary and tertiary education, had significant positive growth effects. An increase in average male secondary schooling of 0.68 years raises annual GDP growth by 1.1% a year; while an increase in tertiary education of 0.09 years raises annual growth by 0.5% a year. They find an interaction between initial GDP and human capital (broadly defined, including health and education), so that countries that lag behind tend to grow faster if they have high levels of human capital.
- In a time series analysis of the UK, Jenkins (1995) looked at an index of total factor (i.e. land, labour and capital) productivity and its relationship to different levels of educational attainment. When higher education qualifications increased by 1%, annual output grew between 0.42% and 0.63%.
- A study in Taiwan showed that higher education played a strong role in the country's economic growth. It found that a 1% rise in higher education stock led to a 0.35% rise in industrial output; and that a 1% increase in the number of graduates from engineering or natural sciences led to a 0.15% increase in agricultural output. This work examined the effects of concentration in different disciplines and concluded that the study of the natural sciences and engineering had the largest effect on output.
- Wolff and Gittleman (1993) showed that university enrolment rates are correlated with labour productivity growth. The number of scientists and engineers per capita is also associated with economic growth.
- In a study of six developed countries, Meulemeester and Rochat (1995) showed that higher education had a strong causal impact on economic growth in Japan, the UK, France and Sweden; but no impact in Italy and Australia. The authors conclude that higher education is necessary for growth, but not sufficient.
- Bloom *et al.* (2004) showed that college graduates in the USA had higher productivity and earnings than non-graduates. Moreover, workers in US states where the proportion of college graduates was high earned significantly more than those in states with few graduates, whether or not they had received a tertiary education themselves.

Finally, Bloom *et al.* (2005) attempt to use a substantial country data set to determine the implications of increasing higher education for economic growth in Africa.

They build on the traditional method for estimating macroeconomic impacts that uses a regression approach to determine the rate of growth of income per capita measured against an initial level of education (such as total years of schooling), with controls for initial levels of income and other factors that may influence steady-state income levels (such as openness to trade, institutional quality and geographic characteristics). The analysis looks specifically at the effects of tertiary education on labour productivity and output per worker as levels of tertiary education increase. The challenge in this method is ensuring that the parameters of the production function are accurately calibrated.

The authors were interested in investigating two different means by which tertiary education can improve economic growth:

1. Raising GDP directly through a productivity effect.
2. Increasing the speed at which a country adopts technology and raises its total factor productivity (i.e. the productivity of labour, capital and land).

The model had two objectives: (1) to measure the effect of increasing any year of education on GDP; and (2) to measure the direct effect of promoting tertiary education in maximising the growth to the production 'frontier' or productive potential of the continent.

After imputing the variables for the technological lag and the effect of higher education on technological catch-up, they found that a one-year increase in the total education stock would raise African GDP by 0.24 percentage points per year. A one year increase in tertiary education stock would however raise African output by an added 0.39 percentage points per year, generating a total increase of 0.63 percentage points per year from increased tertiary education.

The implications of this economic modelling are far reaching:

- If Africa were to double current tertiary education levels from 0.147 years per person to 0.294 years per person, it would increase output from total education by 0.04 percentage points per year. If the increased education were all concentrated in tertiary education stock, it would result in a total gain of 0.12 percentage points per year.
- If Africa were to raise current average individual tertiary education levels to those of the country with the highest rate in the continent (Egypt), from 0.147 years per person to 0.590 years per person, the increase of 0.11 percentage points per year in total education levels would raise Africa's output an additional 0.17 percentage points per year. If the increased education were concentrated in tertiary education stock, the total economic output would increase by 0.28 percentage points per year.
- Finally, Bloom *et al.* (2005) note that the coefficient on education (0.217, implying a rate of return of 21.7%) is higher than, but not significantly different from, the average of the Psacharopoulos studies. This is consistent with the existence of a positive spill-over from private to public returns.

In conclusion, the analysis suggests that increasing tertiary education may be important in promoting faster technological catch-up and improving a country's ability to maximise its economic output. The results show that Sub-Saharan Africa's current production level is about 23% below its potential (as reflected in its 'production possibility frontier' – PPF). The analysis shows that, given this shortfall, increasing the stock of tertiary education by one year could maximise the rate of technological catch-up at a rate of 0.63 percentage points per year, or 3.2 percentage points over five years.

In summary, tertiary education may improve technological catch-up and, in doing so, maximise Africa's potential to achieve its greatest possible economic growth levels. Investing in tertiary education in Africa may accelerate technological diffusion, which would decrease knowledge gaps and help reduce poverty in the region.

Van Heerden *et al.* (2007) undertook a study to measure the impact of universities on the South African economy. Using a 'general equilibrium' model to simulate various scenarios in the analysis of the impact of higher education in South Africa, they present a number of findings relating to income and employment. Three sets of simulations are conducted to determine how strong the secondary or 'knock-on' effects of higher education are on the economy. Each simulation, either directly or indirectly, involves a scenario concerning the higher education sector. First, government expenditure on higher education is hypothetically increased; second, more professionals are trained; and, third, the factors of production are assumed to become more productive.

According to Van Heerden *et al.* (2007) each simulation provides its 'own set of interesting results, (but) it is most significant that when these simulations were combined, the results were positive in almost all respects' (p.iii).

The 'highlights' from the modelling scenarios were described as follows:

1. Increased government spending on higher education by itself (i.e. without accompanying increases in the professional labour force and factor productivity) has negative effects on GDP and most other economic variables. Funds therefore need to be spent selectively before one could claim that additional spending would benefit the economy.

Retraining the existing workforce through higher education would yield positive effects for the South African economy, but is a costly option. For every ZAR 1.50 that the economy would grow, the government would have to spend up to ZAR 2.00 to accomplish the growth.

2. Putting high school graduates through the higher education system would have much higher GDP effects; it is estimated that the effects would be four to five times higher than those of the retraining of other workers.
3. If government spending were to result in more professionals in the market, as well as higher total factor productivity, government would get up to ZAR 1.90 back in revenue for every ZAR 1.00 it spent additionally on higher education.
4. The economy could grow by up to ZAR 11.00 in real terms for every extra ZAR 1.00 spent on higher education, under the assumption that 1% more professionals would be trained, and total factor productivity in the economy would improve by 0.1%.

According to the World Bank (2008), higher and sustained growth rates in Sub-Saharan Africa require a significant increase in physical and human capital over an extended period. It is argued that that there is an urgent need for countries in Sub-Saharan Africa to acquire the capabilities that will spawn new industries that create more productive jobs, multiple linkages and more diversified exports. These capabilities derive from investment in physical assets, such as infrastructure and productive facilities, and in institutions and human capital.

The World Bank (2008) suggests that by raising the level of education and its quality, countries in Sub-Saharan Africa may be able to stimulate innovation, promote the diversification of products and services, and maximise returns from capital assets through more efficient allocation and management. In the face of competition from South and East Asia, a more skills-intensive route to development could provide both resource-rich and resource-poor countries an avenue for raising domestic value added.

It is argued that there are several reasons for prioritising educational quality over quantity at the higher levels of education:

- Quality is more closely correlated with growth. Workers with higher-quality cognitive, technical, communications and team skills are better able to: assimilate technology, push the knowledge frontier, work in groups, and make efficient decisions that build the technological capability for competitiveness; and are the basis for innovation in applied research in fields such as engineering and the biosciences. Such capacity will enable Sub-Saharan Africa to achieve a much higher growth trajectory that facilitates progress towards the Millennium Development Goals (MDGs) in poverty reduction, food security, education and health.
- Tertiary institutions equipped to impart quality education and conduct relevant applied research are also more likely to cultivate multiple linkages with industry and to stimulate knowledge-based development through a variety of proven channels.
- Better quality education can lead to lower graduate unemployment and enable graduates to effectively participate in lifelong learning (World Bank 2008).

According to the World Bank (2008), for the Sub-Saharan African region, the urgency of shifting to a different economic growth path is intensified by:

- Climate change and its profound implications for water availability, agriculture and the tourist sector.
- Pressures generated by AIDS and other diseases that affect dependency ratios, fertility, labour productivity, primary enrolment, school attendance, the number of orphans, early childhood nutrition, and many other factors.
- Tensions arising from the growth of the population and labour force, migration to cities, and the 'youth bulge'.
- Economic vulnerabilities created by unequal distribution of incomes.
- Lags in exploiting new farming technologies that could increase productivity and decrease vulnerability to pests and weather extremes.
- Problems with planning and implementing projects, and with regulating and maintaining physical infrastructure.
- Brain drain and high mortality among the educated because of AIDS, which has exacerbated the shortage of skills.
- An underdeveloped institutional infrastructure, which is responsible for the unfavourable business climate, technological backwardness, failing tertiary institutions and chronic social unrest.

Higher rates of growth will require gains in the efficiency of resource use and in total factor productivity derived from advances in technology. Accelerating growth, viewed from the perspective of supply, requires, in the view of the World Bank (2008):

- Sharp gains in allocative efficiency, mediated by public agencies, the financial system, and the business sector.
- Substantially increased efficiency in utilisation of capital assets (infrastructure and industrial), and sustained efforts to maintain them.
- Steady improvement in the capacity to identify and assimilate relevant technology,

make incremental advances, and harness technology for purposes such as producing tradeables, improving public health, and conserving energy and water.
- Accumulation and deepening of managerial and organisational skills and experience, both to support industrialisation and international economic relations and to cope with the trends towards decentralisation and urbanisation.

All these require an increase in the ratio of skilled and technical workers to capital, at a relatively early stage of development. Trained workers and professionals not only provide technical knowledge and promote innovation, they also serve as allocators of resources, and as coordinators and equilibrators who can recognise and exploit technological possibilities.

No matter which option is chosen for accelerating growth or how the supply constraints are addressed, African nations will need to produce a larger pool of good quality tertiary graduates and postgraduates; and to produce them particularly in the disciplinary fields relevant to a country's chosen strategy for economic development. Despite strong enrolment growth, most African tertiary institutions are not generating enough graduates – and many of them lack the skills needed to support national economic development in the 21st century.

Important factors identified in the World Bank publication (2008) include:

- The slow growth of public higher education financing.
- The low proportion of science and engineering students.
- The lack of institutional autonomy to make decisions and adapt to changing labour market conditions.
- Inappropriate curricula vis-à-vis the needs of the labour market leading to high levels of graduate unemployment.
- Poor working conditions and salaries leading to high levels of attrition among academic staff.
- Inadequate and inappropriate technology.
- A reluctance to adopt the 'third mission' – support for the economy.

The World Bank believes that making tertiary education a driver of growth requires adoption of a number of good practices, especially the following:

- Developing a strategy for national human resource development.
- Granting institutional autonomy coupled with appropriate accountability mechanisms in order to increase opportunities for system differentiation and institutional innovation.
- Reforming financing arrangements to offer incentives for attaining policy goals while providing the stability necessary for institutions to plan strategically.
- Encouraging diversity in teaching and learning approaches that facilitate institutional specialisation.
- Fostering the development of national and regional postgraduate programmes – the best way to increase academic staff numbers and build research capacity.
- Searching for lower-cost delivery alternatives for tertiary education.

Chapter 3
Higher education and the knowledge economy[2]

Knowledge accumulation and application have become major factors in economic development and are increasingly at the core of national competitive advantage in the knowledge economy (OECD 2008). The role of tertiary education in the construction of knowledge economies is crucial. Many developing countries, however, continue to wrestle with challenges relating to: expanding education coverage in a sustainable way; inequalities of access and outcomes; educational quality and relevance; and inflexible governance structures and management practices.

In recent years, key organisations, such as the World Bank, and major donor governments have conceded that tertiary education may have a positive impact on economic development after all. Donors have come to accept that in a multi-pronged development strategy, all levels of education are important.

In 1999, the World Bank published *Knowledge for Development,* a report that looked at how developing countries could use knowledge to narrow the income gap with rich world economies. It showed a correlation between education in mathematics, science, and engineering, and improved economic performance. It also showed that the private rate of return to tertiary education, at 20%, was similar to that for secondary schooling. The report recommended that developing countries train teachers using distance learning and create open universities that use satellites and the internet to deliver courses.

In its later report, *Higher education in Developing Countries: Peril and Promise*, the World Bank (2000) argued that higher education is essential to developing countries if they are to prosper in a world economy where knowledge has become a vital area of advantage.

A subsequent World Bank (2002) report, *Constructing Knowledge Societies: New Challenges for Tertiary Education*, stressed the role of tertiary education in building technical and professional capacity, and bolstering primary and secondary education. Although the report maintained the World Bank's emphasis on primary and secondary schooling, it also argued that the state should create enabling frameworks to encourage tertiary education institutions. Countries, it suggested, should not focus only on the rate of return analyses, but also take account of the 'major external benefits' of higher education.

In a further progression, the World Bank (2007) published a major report on the knowledge economy. This publication identified three main messages:

- **Message 1**: Knowledge and innovation have played a crucial role in development from the beginnings of human history. But with globalisation and the technological revolution of the last few decades, knowledge has clearly become the key driver of competitiveness and is now profoundly reshaping the patterns of the world's economic growth and activity. Both developed and developing countries should therefore think, with some urgency, 'about their future under a knowledge economy heading' (p.xiv).

- **Message 2**: To become successful knowledge economies, countries have to rethink and act simultaneously on their education base, their innovation systems, and their ICT infrastructure, while also building a high-quality economic and institutional regime. Policies for these four pillars have to reflect the country's level of development and will often have to be gradual. However, experience shows that some successful knowledge economy champions have been able to achieve spectacular leaps forward within a decade.
- **Message 3**: Many if not most of the countries that have made rapid progress have staged nationwide knowledge economy-inspired programmes of change. Such programmes have been pragmatic and country-specific, yet some common points emerge: the need to promote trust and social cohesion around the knowledge economy programme; the need to work at the four pillars through a combination of top-down reforms and bottom-up initiatives; and the need for a well-communicated knowledge economy vision.

The role of tertiary education in the knowledge economy

In the knowledge economy tertiary education has become far more widespread than in earlier generations. The development of a class of knowledge workers is transforming labour forces and economies. As electronic devices and robots increasingly accomplish human tasks, the need for routine skills – both manual and cognitive – is decreasing, while the demand for expertise and communication skills of all kinds is rapidly rising. The need to understand and interact with images and data is increasing the demand for analytical and integrative skills in even basic functions. This phenomenon stretches educational and organisational systems, as they straddle specialised and generalised skills.

Also, although research on the impact of the knowledge economy on employment creation and growth is still at a preliminary stage, efforts have begun, particularly in advanced economies, to quantify its effects. Brinkley and Lee (2006) studied rates of job creation in knowledge-based sectors and low-knowledge sectors in the European Union and USA over a ten-year period. They found that knowledge-based industries created twice as many new jobs in the USA and four times as many in Europe.

The World Bank (2007) also reported that industrialised countries, for which the term 'knowledge economy' was initially derived, are coping unevenly with the new realities. The nations of North America seem to have benefited quickly from the new opportunities offered, with a higher growth rate and higher productivity performances over the last 15 years or so. Gaps in income per inhabitant between North America and Europe have increased. In Europe, small, dynamic economies such as Finland have become models of knowledge-based growth and competitiveness; while larger continental economies such as France and Germany – which led the technological and industrial race in past decades – have had difficulty adjusting. Meanwhile, Japan has experienced a difficult decade, with slow growth caused by a variety of factors, but has continued to build knowledge economy assets (by increasing spending on basic research, for example) and to maintain the competitive edge of its global manufacturing companies. The Republic of Korea, meanwhile, has actively embarked on a knowledge economy track to recover from the financial crisis of 1997/1998.

On the whole however, there is a strong correlation between innovation performance, total factor productivity, and economic growth in OECD countries. Nordic and English-speaking countries have, as a whole, performed better than others.

The transition economies of Eastern Europe have had difficulty coping with the new knowledge-based competition, although they benefited from considerable past investments in education and science. Smaller economies such as Hungary, Slovenia and Estonia have coped well and taken advantage of European enlargement. Estonia, in particular, has adopted an aggressive knowledge economy approach. However, a number of other new EU members and candidates are undergoing a more painful adjustment process. The Russian Federation and other countries of the former Soviet Union have yet to demonstrate their capacity to make use of a knowledge potential that was considerable at the time when the Berlin Wall fell but eroded rapidly owing to the migration of highly educated people.

Among medium- and low-income countries, Chile, Malaysia and Tunisia have clearly taken a knowledge-based approach to increasing competitiveness and growth. World Bank (2007) research on economic growth shows that countries with successful growth – defined as those that both caught up with advanced countries' growth rates and sustained growth over time – did so by combining three important factors: capital accumulation, efficient resource allocation, and technological catch-up. According to this report (World Bank, 2007), the 18 successful countries were China, Vietnam, the Republic of Korea, Chile, Mauritius, Malaysia, Lao People's Democratic Republic, India, Thailand, Bhutan, Sri Lanka, Bangladesh, Tunisia, Botswana, Indonesia, Arab Republic of Egypt, Nepal and Lesotho. The report underscores the importance of technological catch-up and its translation into economic growth through increases in total factor productivity, which accounted for between one-half and three–quarters of economic growth in all countries listed.

According to the World Bank, each government among the 18 countries listed played a unique role in the growth process. China embarked on a knowledge-based growth track by attracting massive foreign direct investment (FDI) and then building an indigenous knowledge base through huge investments in education and research. India has succeeded by making the best use of its elite education institutions and exploiting international IT-related opportunities, in part through the deft use of knowledge assets.

The knowledge revolution and the technological and economic changes it implies clearly entail the need to rethink countries' overall development strategies. According to the World Bank (2007), knowledge- and innovation-related policies should be at the core of those strategies, which should be built on four pillars: the country's education and training base; its information and telecommunications infrastructure; the innovation system; and the overall business and governance framework. The last of these pillars conditions the effectiveness of investments in the other three.

The knowledge economy and economic performance

To monitor its new emphasis on knowledge, the World Bank has created a Knowledge Economy Index (KEI). This index benchmarks countries' performance on four aspects of the knowledge economy: the favourability for knowledge development within the economic and institutional regime; education; innovation; and ICT.

Levels of economic development and levels of knowledge should be closely related. The correlation between knowledge accumulation as measured by the KEI and levels of economic development is 67%. However, the positive relationship between the results of the KEI and the level of economic development does not establish a causal relationship – a high KEI will not necessarily produce a high level of economic development. On the other hand, it is plausible that high-income countries, because they are more affluent, are able to afford greater investments in knowledge and thus score higher on the KEI. However, countries that score higher on the KEI do have higher levels of economic development, and vice versa. In fact, econometric tests reveal a statistically significant causal relationship running from the level of knowledge accumulation as measured by the KEI to future economic growth.

It is clear that higher KEI values are associated with higher rates of future economic growth, if other factors are held constant. This suggests that higher levels of knowledge in a society do indeed lead to higher levels of economic growth – and consequently to higher levels of economic development. A one-unit improvement in the KEI, equivalent to moving up one decile or 13 positions in the country rankings, leads to an increase of 0.46 percentage points in economic growth, after accounting for initial conditions (World Bank 2007). With the countries stratified into four income categories, the overall conclusion was that the growth effects of knowledge accumulation are important at all levels of economic development.

To understand how to build knowledge-based economies, it is useful to look at countries that have succeeded in setting their growth processes on a knowledge-and innovation-based track – even if the relevant policy actions were part of broader development strategies, and an explicit knowledge economy approach was only recently identified and named. Several cases throughout the world deserve particular attention.

Amongst industrially-advanced economies, Finland is considered by many to be the world's most competitive country. Canada and Australia also enjoy competitive economies. The Republic of Korea and Ireland initiated explicit knowledge economy strategies in the past few decades starting from a low-income base to achieve leading positions in the world economy.

Amongst middle-income economies, a few decades ago the nations of Chile and Costa Rica in Latin America, Malaysia in East Asia, Tunisia in North Africa, and Mauritius and Botswana, instituted multi-sector reforms to attract foreign investment and create a knowledge economy-oriented environment.

Amongst transitional economies, the Baltic countries, notably Estonia, have instituted knowledge economy reforms over the past decade that are now paying off.

Amongst low-income economies, Vietnam has developed rapidly by taking advantage of globalisation. The African countries of Mauritania, Mozambique, Uganda and Rwanda are also instituting knowledge economy reforms (if in a fragmented way) and have enjoyed some economic success. Most African countries languish near the bottom of the KEI. South Africa, Botswana, and Mauritius record scores near the middle, but Nigeria, Cameroon, Malawi, Tanzania and others have struggled, scoring less than two out of a possible ten points.

Building on the World Bank's formulation of the four pillars of a knowledge-based economy, which focuses on the economic dimension, the Asian Development Bank (2007) has developed an alternative framework that combines the two globally emergent development paradigms: sustainable development and knowledge management. If the knowledge-based economy framework is broadened to encompass also planning for a knowledge-based society and a knowledge-assisted caring for the environment, then the resulting broader framework can be called knowledge-based development (see Table 3).

Table 3 : A model of knowledge-based development (KBD)

	Economic (knowledge-based economy)	Social	Natural
Education (development of human capital)	Education for a skilled workforce	Education for total human development	Education for sustainable development
Innovation (development of structural capital)	Systems, processes, and technological innovations	New institutions and protocols for peace, equity and human rights	Environmental technologies, e.g. renewable energy technologies
Building networks (development of stakeholder capital)	Financial and physical networks, e.g. ICT infrastructure	Social networks, social trust, cultural integrity	Agreements to protect and sustain planetary life support systems

Source: Asian Development Bank (2007)

The World Bank's four pillars of a knowledge-based economy and the corresponding scope of knowledge assessment methodology fit precisely the three categories of intellectual capital applied to the economic domain ('Economic [knowledge-based economy]' in column 2 of Table 3):

- Education for a skilled workforce is development of human capital.
- National innovation systems represent the development of structural capital.
- ICT infrastructure is development of technical aspects of stakeholder capital, while policy and regulatory environment is about the non-technical aspects of stakeholder capital.

What can developing countries do?

Tertiary-level and research institutions in low-income countries need to focus on creating a pool of experts capable of adopting science and technology and adapting it to the local context. In particular, this means changing the current paradigm to include – in addition to teaching and research – a third mission: service to the community and close cooperation with the public and private sectors to contribute to innovation and development. It is imperative that universities work towards fulfilling their mission of social responsiveness – a mission that has been promoted in industrialised countries over the past two to three decades (OECD 2008).

Another necessary change in the current academic paradigm is the need to tap into global knowledge by creating regional networks and communities of practice, poles of excellence, and both South-South and North-South partnerships between institutions. Finally, given resource constraints, tertiary-education and research institutions need to undertake managerial and financing reform to reinforce their autonomy and their competitiveness.

In sum, at the tertiary level, policy needs to be pragmatic and flexible to help build a qualified labour force that is able to adapt to changing demand in both local and global markets. As Table 4 shows, this may imply a shift from public financing to public-private partnerships and the implementation of:

- Curricula that include the knowledge and skills required for the new economic context.
- The new mixed-mode teaching to complement traditional face-to-face teaching.
- More open policies toward society and the private sector (OECD 2008).

Table 4: Higher education policy requirements for the knowledge economy

Traditional policy orientations	Knowledge economy requirements
• Public Financing • Traditionally separate disciplines • Face-to-face teaching • Inward orientation focused on academic communities • National standards and cooperation with national institutions	• Public-private partnership • New knowledge adapted to social and economic requirements • Mixed modes with distance and e-learning components • Opening to local communities and the business sector • Inclusion in global networks of higher education institutions, with access to related performance evaluations

Source: OECD (2008)

Chapter 4
Higher education and regional development

As a recent OECD publication (2007:11) shows, rich countries are putting considerable emphasis on meeting regional development goals, 'by nurturing the unique assets and circumstances of each region', particularly in developing knowledge-based industries. As key sources of knowledge and innovation, higher education institutions can be central to this process.

In the past, neither public policy nor the higher education institutions themselves have tended to focus strategically on the contribution that they can make to the development of the regions where they are located. Particularly for older, more traditional higher education institutions, the emphasis was often on serving national goals or on the pursuit of knowledge, with little regard for the surrounding environment.

To be able to play their regional role, it is evident, the OECD (2007) research notes that higher education institutions must do more than simply educate and research – they must engage with others in their regions, provide opportunities for lifelong learning and contribute to the development of knowledge-intensive jobs which will enable graduates to find local employment and remain in their communities. This has implications for all aspects of these institutions' activities – teaching, research and service to the community, and for policy and regulatory framework in which they operate.

The OECD (2007) report explores the policy measures and institutional reforms that can help HEIs live up to these challenges. It considers regional engagement of higher education in several dimensions, notably: *knowledge creation* through research and technology transfer; *knowledge transfer* through education and human resources development; and *cultural and community development,* which can, among other things, create the conditions in which innovation thrives.

The OECD (2007) research shows that examples of higher education helping to serve the needs of local economies can be found in various countries over the past 150 years. However, these links have been sporadic rather than systematic. This has changed dramatically with recent expansion of higher education, particularly in the non-university sector, which in some cases has consciously aimed to address regional disparities and to widen access. Another important factor changing the context of regional development has been a switch towards more indigenous development, which emphasises the building of skills, entrepreneurship and innovation within regions. Growing efforts have been made to remove barriers to the application of research, which obliges higher education institutions to become involved in innovation. Policy responses which initially focused on enhancing the capacity for technological innovation through technology transfer and interactions between higher education institutions and private industry have now widened to include public services, social and organisational innovation, and to engage higher education institutions in the wider social fabric of which they are part.

Regions and higher education institutions are building partnerships based on shared interest, which is principally economic. From the perspective of agencies promoting city and regional development, higher education institutions have become a key resource. They can help serve regional development most obviously by contributing to a region's comparative advantage in knowledge-based industries and to its human capital base; but also, for example, by helping to generate new businesses, by contributing to tax revenues and by providing content and audience for local cultural programmes. From the perspective of higher education institutions, regional involvement has a range of benefits. The local area brings business to institutions in a variety of forms, including student enrolments and payments for research, consultancy and training. At the same time, a thriving region creates an environment in which higher education can also thrive, helping institutions to attract and retain staff and students (OECD 2007).

In the regions involved in the OECD study, partnerships are being developed between higher education institutions and the public and private sector to mobilise higher education in support of regional development. The partnerships, which are in most cases at early stages, are often bottom-up initiatives with limited support from central government. The early stages are characterised by numerous small-scale and short-term projects championed by key individuals.

The OECD (2007) research notes that more active engagement is constrained by the orientation of public policy, inadequate funding and incentives, limits to leadership within higher education institutions, and the limited capacity of local and regional agents to get involved with higher education. Regional engagement strategies of higher education institutions depend on the role the higher education institution chooses for itself and the leadership role it adopts. The governance, leadership and management of higher education institutions can constrain active engagement. Also, traditional academic values give little weight to engaging with local communities. Furthermore, institutional structures within higher education institutions offer limited incentives or resources to pursue activity that serves the region.

The OECD (2007) report points out that national higher education systems may impose regulations that reduce the capacity of higher education institutions to engage regionally. Administrative-based higher education systems leave little room for institutional autonomy and flexibility. In many unitary countries, higher education policy does not include an explicit regional dimension. The report suggests that ministries of education need to balance conflicting policy priorities and may show limited interest in higher education institutions' regional engagement. Applied research and development, and meeting skills needs in the local labour market, are left to institutions which often lack a well-established tradition in research or infrastructure to support it. Even when engagement with business and the community has been recognised and laid upon higher education institutions as a 'duty' by national governments, it has remained a 'third task' – not explicitly linked to the core functions of research and teaching.

The OECD (2007) report shows also that funding and incentive structures have often provided limited support for regional engagement. Higher education institutions are faced with competition, new tasks and pressures to reduce cost, notably by the central authorities. This context does not necessarily favour an enhanced regional role for higher education institutions. Research is generally funded on a geographically neutral basis or aims to create critical mass. Funding for teaching is weakly oriented towards building human capital in deprived regions and higher education's role in aiding community development is not systematically funded. Regional engagement is generally not supported by major incentives or monitoring of outcomes.

The OECD (2007) research shows further that regional structures and governance are in many instances ill-suited to furthering the regional agenda of higher education institutions. The territorial coverage of local and regional government is constrained to serving fixed constituencies, whereas higher education needs to define its sphere of influence in a flexible way. Local governments do not always have responsibilities that allow them to engage freely in economic development. Higher education institutions and firms often experience significant gaps in their collaborative relations: academics may be uninterested in tackling seemingly mundane problems and/or failing to deliver solutions on time or to budget, while firms may lack sufficient information to track down the appropriate expertise within the higher education institutions. Restrictions on publishing research results also set constraints.

The report puts forward a set of proposals for overcoming the barriers to regional development.

Overcoming barriers to promoting innovation with a regional focus

Despite the existing constraints, the new tasks of higher education institutions have increased as countries have reinforced the higher education institution apparatus in relation to firms and regional economies. The policies have a common goal: to transform each higher education institution into an engine for growth. The efforts have often been indirect, i.e. granting enhanced autonomy to higher education institutions and improving framework conditions and incentives to cooperate with the private sector. Two prominent ways have been: (1) enhancing the role of tertiary education within regional innovation systems; and (2) enhancing the participation of higher education institutions in cluster type initiatives. Temporary incentives have been developed in the form of grants, calls for projects or joint programmes. Policies have often prioritised the uptake and development of high technologies, while mechanisms to support social entrepreneurship and innovation for wider needs of excluded groups in rural areas and inner cities have been limited. There has also been less emphasis on services, which account for 70% of the workforce in the OECD countries.

Case studies from different countries show how a regional dimension can be integrated into public investment in the science base in higher education institutions. For example, in France, Finland, Japan, Mexico and the UK, national governments have taken steps to identify and support regional centres of innovation. Examples from Atlantic Canada illustrate how higher education institutions can work together to improve and diversify their supply of services for local and regional firms. Small and medium-sized enterprises do not always find it easy to work with large higher education institutions or to engage in the wider research issues raised in universities. Creating access points can help smooth this process. Case studies illustrate how this is done in the north-east of England with a 'Knowledge House', which provides a common entry point to five universities; and in the USA at Georgia Tech, which has 13 regional offices throughout the state (OECD 2007).

Overcoming barriers to developing human capital within regions

The report notes that higher education can contribute to human capital development in the region through educating a wider range of individuals in the local area, ensuring that they are employable when they leave education, helping local employers by responding to new skills requirements, ensuring that employees go on learning by supporting continuous professional development, and helping to attract talent from outside.

Widening access to higher education is a national as well as a regional task, but the regional dimension is particularly significant in countries with wide disparities. Some countries, e.g. Australia, have introduced a specific regional dimension to the higher education equity initiatives. Given that one-third of working-age adults in the OECD countries have low skills, up-skilling and lifelong learning are particular challenges. In Finland, the Provincial University of Lapland has pooled the expertise of four HEIs to reach out to remote communities in cooperation with stakeholders (OECD 2007).

Higher education institutions can also improve the balance between labour market supply and demand. This requires labour market intelligence and sustained links with local businesses, communities and authorities. Work-based learning programmes represent person-embodied knowledge transfer which often culminates in job creation and promote links between SMEs and higher education institutions. Aalborg University in Denmark and many new higher education institutions have built their education provision around problem-based learning, which guarantees a high degree of cooperation with the society and the private sector (OECD 2007).

Higher education institutions are also increasingly creating entrepreneurship programmes. The emergence of a well-functioning human capital system in the region, as distinct from a number of disconnected components, requires some degree of coordination and steering, not least between different stages of education. Cooperation among higher education institutions can bring numerous advantages, including critical mass in competing with other regions, improvement of pathways that involve enrolment at multiple institutions, and the sharing of learning through the dissemination of best practice.

Overcoming barriers to promoting the social, cultural and environmental development of regions

The OECD (2007) report points out that regional development is not only about helping businesses thrive: wider forms of development both serve economic goals and are ends in themselves. Higher education institutions have long seen service to the community as part of their role, yet this function is often underdeveloped. The report points out that few OECD countries have encouraged this type of activity through legislation and incentives. The mandatory social service for higher education students in Mexico provides an interesting model for countries seeking to mobilise higher education towards social goals.

Many higher education institutions have a strong involvement with health, and this can be turned to community use – for example, the universities in north-east England work with the Strategic Health Authority to address public health issues in the region. Higher education can be well placed to analyse and address social needs in deprived areas. For example, in Central Finland, the Jyvaskyla University of Applied Sciences is working with a wide range of stakeholders to develop social innovation to help long-term unemployed people back into work (OECD 2007).

In the cultural domain, the contribution made by culture to quality of life, the attraction of creative talent and the growth of creative industries are all part of regional development. Higher education can be a major player in internationalising their regions and making them more diverse and multicultural, but often not enough is made of international links in this regard. Higher education institutions can also play a significant role in environmental development, for example by mustering expertise and by demonstrating good practice.

The OECD (2007) report also shows that in regional engagement much depends on the institutional leadership and entrepreneurialism of higher education institutions. Mainstreaming the regional agenda and scaling up the institutional capacity from individual good practice cases to a well-developed system requires senior management teams who are able to deliver the corporate response expected by regional stakeholders, modern management and administration systems, transversal mechanisms that link teaching, research and third-task activities and cut across disciplinary boundaries, permanent structures that enhance regional engagement (e.g. regional development offices and single entry points to higher education expertise, such as Knowledge House in north-east England), and sufficient incentives (e.g. by making regional engagement a consideration in hiring and reward systems, as has been done in the University of Sunshine Coast in Australia). There is also a need to ensure that units established to link the higher education institutions to the region, such as science parks, centres of continuing education and knowledge transfer centres, do not act as barriers to the academic heartland or provide an excuse for detachment. Finally, there is a need to acknowledge that regional engagement can enhance the core missions of teaching and research and that the region can be seen as a laboratory for research projects, a provider of work experience for students and a source of financial resources to enhance the global competitiveness of the institution.

The OECD (2007) research also demonstrates that higher education institutions play an important role in partnering with regional stakeholders. Many OECD countries have strengthened this role through requiring higher education governance to include regional representation and encouraging the participation of higher education institutions in regional governance structures. Some countries, e.g. the UK and Finland, have also encouraged closer cooperation between higher education institutions in the region, through, for example, joint degrees, research programmes, strategies, higher education regional associations and one-stop shops for industry collaboration. Stronger commitment can be achieved when higher education institutions are mobilised not only in the preparation but also in the implementation of regional strategies backed up with necessary financial resources. A crucial step is to create well-functioning coordinating bodies at the regional level that comprise the key regional actors, including the private sector, and that take a long-term wider view of regional development – not just focusing on economic, but also social, cultural and environmental development.

Finally, the OECD report shows that higher education institutions can play a key role in joining up a wide range of national policies at the regional level. These polices include science and technology, industry, education and skills, health, culture and sport, environmental sustainability and social inclusion. Countries which wish to mobilise their higher education system or part of it in support of regional development, need to ensure that the higher education policy which embraces teaching, research and third-task activities include an explicit regional dimension. Countries also need to create beneficial framework conditions, such as strengthened institutional autonomy that supports more entrepreneurial higher education institutions and their cooperation with enterprises, as well as supportive incentive structures, including long-term core funding as well as additional strategic funding schemes.

Universities, innovation and local economies

The relationship between tertiary education institutions (especially universities) and local economic development is a severely under-researched area. An important question in this regard is how tertiary education institutions can contribute to the capabilities of local firms to take up new technologies and market knowledge and to apply it effectively.

This section draws heavily on a report on the Local Innovations Systems Project at MIT (Lester 2005), which shows how universities can support local economic development through their contributions to local industrial innovation processes.

For university administrators, the new focus on what is sometimes referred to as the 'third-stream' mission of economic growth (to differentiate it from the traditional missions of education and research) has generally been a welcome development, in part because of its promise of new revenues at a time when traditional revenue sources are under increasing pressure. And as the gap between academic laboratories and the marketplace has shrunk, universities, teaching hospitals, and other academic units have become more adept at the commercial exploitation of academic research.

The rising interest in the university's economic development role has been fuelled by high-profile examples of successful regional economies in which the university contribution is easily identified, such as Silicon Valley, North Carolina's Research Triangle Park, the

Boston area in the USA, and the region around Cambridge in the UK. Less widely publicised are cases of 'blockbuster' licenses on university-developed and patented technology. Both kinds of success have helped to promote what has now become a standard view of the university's economic role, centering on technology transfer. The technology transfer model starts with discoveries by university researchers in their laboratories, and proceeds to disclosure by the inventors, patenting by the university or the inventor, and ultimately licensing of the technology, frequently to start-up or early-stage technology-based enterprises founded by the inventors themselves.

The overall economic significance of this model, as well as its promise in particular situations, has often been exaggerated. Part of the problem is the failure to recognise that the best-known success stories are atypical. The university origins of enormously successful companies like Cisco, Google and Yahoo (all three of which grew out of Stanford University research and two of which took Stanford licenses) are well known. Less often noted is the fact that new business formation around university science and technology is a very small fraction – probably no more than 2–3% – of the total rate of new business starts in the USA.

The same is true of patenting. Even in the USA, where patenting by universities is most common, it is only a minor contributor to the overall stock of patented knowledge. About 3 700 patents were granted to US universities in 2001 out of a total of about 150 000 US patents issued in that year. Moreover, even the most prolific patenting universities are not particularly active by corporate standards.

In 2002, in an effort to develop a broader perspective, an international team of researchers based at the MIT Industrial Performance Center began studying specific cases of industrial transformation in different locations. The overall goal of the Local Innovations System Project (LISP) was to examine the role of innovation in the emergence and transformation of local industries. In the first phase of the research, the focus was on the contribution of universities to local industrial development through their participation in local innovation processes.

The researchers adopted an 'outside-in' perspective on the university role. Their starting point was that the local economy in which a university is situated can be described as a set of industries, each of which produces a mix of products and/or services that change over time. The economic health of the economy depends ultimately on the outcome of these evolutions. A successful local economy is one in which significant numbers of local firms adapt to new market and technological opportunities by introducing commercially successful new products or production processes repeatedly over time. Not all local economies adapt with equal success, and within the same locale, different industries perform differently. The outcome depends at least partly on the abilities of local firms to *take up* new technologies (and new knowledge more generally) and *to apply* this knowledge productively. The focus here was on the contributions made by local universities to those capabilities.

Research was conducted in 22 locations in six countries (USA, UK, Finland, Norway, Japan and Taiwan). In each case, the focus was on a particular industry or line of business and in each case the researchers selected a time period for study which generally ranged between two and three decades. The researchers traced the development of the industry over this period, focusing on the contribution of local innovation processes to the evolution of products, services and production processes.

The industries in the sample included both mature sectors (industrial machinery, automobile manufacturing) and new fields (bioinformatics, opto-electronics). The locations include relatively prosperous, 'high-tech' regions (Boston, Cambridge in the UK), as well as economically less-favoured regions. About half the locations were outside the USA. Some of the locations were home to first-tier research universities, others to universities that were not in the front rank, and still others had no universities at all. Thus, though constructed opportunistically rather than scientifically, the case portfolio incorporated a broad range of technological, industrial and institutional environments.

In reporting their findings, the researchers note that each of the cases is unique. However, to simplify matters, they produced a useful typology of industrial transformation processes, namely: (1) indigenous creation; (2) transplantation from elsewhere; (3) diversification into technologically-related industries; and (4) upgrading of existing industries.

The four types of transformation are idealised. In practice the distinctions between them are not always clear. For example, when the firms in a local industry move along the value chain from components to systems (e.g. the Kyoto, Japan, electronics manufacturers) or from systems to associated services (e.g. the Tampere, Finland, machinery producers), do these represent cases of upgrading or diversification? Furthermore, the development of an industry in a particular location may involve more than one kind of transition at the same time. For example, the initial development of the oil and gas industry in Stavanger, Norway, was made possible by the decisions of multinational oil firms to locate there; but local engineering, construction and shipbuilding firms diversified into the new industry and later achieved international successes in this field. (In Aberdeen, Scotland, only one local firm – a fishing and ship repairing concern – made that transition.)

Despite these complications, the taxonomy is useful. For most of the cases, one type of transition clearly dominated. And taken together, the cases strongly suggest that the skills, resources and institutional capabilities associated with each type of transition are different, and that each is associated with a distinct pattern of technology take-up and application. The roles of local universities also appeared to vary considerably depending on which kind of transition was occurring.

In every case, the outcome of the transition hinged on the ability of the firms in the region to identify new technological and market opportunities, and to develop or absorb and then apply new technological and market knowledge. In every case it was the actions of individual firms, motivated by profit, responding to market signals, and applying their knowledge of the marketplace, that ultimately determined the outcome. But in every case, too, the innovation performance of these firms depended on more than their own internal capabilities and strategies. It was also affected by the behaviour and performance of local supplier and customer firms, producers of complementary goods and services, and financial intermediaries, as well as local and regional education and training institutions, universities, other public research institutes and foundations, and government agencies and programmes concerned with innovation, both promotional and regulatory. Less tangible attributes of the locale were often also important, such as attitudes towards innovation and entrepreneurship, and the quality of local leadership. All these elements comprise the local innovation system, and the cases make clear that the demands placed on such systems vary depending on what kind of transition is involved.

In cases of new industry creation, a local university or public research laboratory typically played the role of anchor institution; whereas in the case of industry upgrading the anchor institution was more likely to be a lead firm or a lead customer. In science-based industry formation the highest-impact educational outputs of local universities were PhD-level scientists and engineers with an interest in entrepreneurial careers and some exposure to entrepreneurial business practices. For cases of upgrading, bachelors- and masters-level engineering graduates equipped with knowledge of the industry's practices and problems obtained from classes, practical theses, and internships were of greatest value. For science-based industry creation, university technology transfer was active and oriented towards start-ups and small firms. For industry upgrading these arrangements were more likely to centre on long-term relationships between the university and established firms. In some cases of new industry creation, a local university played a leading role. But none of the upgrading processes were university-led, although in some cases local universities played important supporting roles.

University participation in local industrial transformations

The cases make clear that universities engage with their local communities in many different ways. Even within the purely economic domain there are important aspects of the university role that the MIT study (Lester 2005) did not consider. In many communities the university is one of the largest employers, and it is often a major consumer of products and services produced by the local economy. Universities may also be important owners of local real estate. A university's contribution to local innovation processes is thus only a part – often just a small part – of its local presence. But even within this relatively narrow frame the cases revealed multiple channels of engagement, which can be grouped into four broad categories:

- **Education and training**: Universities make important contributions to local human capital development at the undergraduate, masters, doctoral, mid-career and executive education levels.
- **Adding to the stock of codified knowledge:** This includes publications in the technical literature, patents, and software and hardware prototypes.
- **Increasing the local capacity for scientific and technological problem-solving**: This includes various forms of support for the creation and development of new technology-based enterprises, such as venture mentoring programmes, start-up clinics, and incubators. It also includes contract research carried out by university researchers for industry, cooperative research projects carried out jointly by university and industry researchers, faculty consulting, and technology licensing. Universities may also contribute by giving local firms access to specialised instrumentation and equipment.

- **Providing space for open-ended conversations about industry development pathways and new technological and market opportunities**: These 'public spaces' – some of them focused on particular industries, others not – include university-hosted meetings and conferences, standard-setting forums, forums for potential investors (e.g. venture capital investors), business plan contests, industrial liaison programmes, alumni networking activities, and visiting committees and curriculum development committees involving local industry practitioners.

The impacts of these activities may extend far beyond the university's own neighborhood. This is most obviously true of the prolific research universities. They are genuinely international institutions, educating students from around the world, contributing to the international research literature, interacting with firms and governments from many countries, and employing on their faculties internationally recognised intellectual leaders from around the world. But even for these 'global' universities, the economic impact of their activities is skewed towards their local communities. For other universities the economic impacts are even more heavily skewed to the local.

A related study (Santoro & Chakrabarti 2001), which sought to determine what firms look for in their university relationships, examined 21 university research centres and nearly 200 collaborating firms. It found that for some firms the main goal was to enlist university researchers in problem-solving activities directly related to their primary business. In these interactions the impact on the company's bottom line was the dominant measure of performance. But for other firms the most important goals of their interactions with the university were to participate in activities and exchanges that would enable them to become privy to the latest thinking in fields relevant to their business, and to have an influence on the future direction of related curricula at the university. Firms in the second category tended to be larger, and the universities with whom they collaborated tended to be those in the elite group. The more problem-solving-oriented collaborations were more likely to involve small and medium-sized firms and lower-ranked universities.

The most important finding from the four cases is that the university role in local innovation processes depends on which industrial transition pathway is being followed. Although it is common to find many if not most of the activities listed above at any given university, a tendency was observed for certain activities to be most closely associated with particular development pathways.

For Type I transitions involving the creation of a new science-based industry, important activities include providing various kinds of support for new business formation, pro-active technology licensing programmes and policies, and efforts to broker ties between academic researchers and local entrepreneurs. Key individuals at the university may also play important roles in establishing an identity for the new industry, convening conferences and workshops, initiating standard-setting activities, and generally acting as industry 'evangelists' by drawing attention to the existence of local concentrations of related activities and by painting a picture of future impact and growth potential.

For Type II transitions involving the relocation of industries into the region, important university activities include responding to the local human resource needs of the relocating firms, especially by developing new, customised curricula and continuing education programmes. Another important role was to provide technical assistance to local suppliers and sub-contractors.

For Type III transitions involving diversification out of existing local industries into technologically related new ones, a key role for the university is to cultivate technological links between disconnected actors; for example, by establishing on-campus forums for discussion of new applications of local industrial technologies. Another important role is to help build the identity of the new industry locally.

Finally, for Type IV transitions involving the upgrading of the technological base of existing industries, local universities contribute to technical problem-solving through contract research and staff consulting, developing industry-relevant degree and continuing education programmes, creating internship and staff leave opportunities in the local industry, convening foresight exercises and user-supplier forums on campus to discuss the future development of the industry, and participating in global best-practice scanning activities with local industrial practitioners.

These findings cast doubt on the usefulness of a one-size-fits-all approach to economic development that so many universities have been pursuing, with its focus on patenting, licensing, and start-ups. They instead suggest the need for a broader, more differentiated view of the university role. Not all local economies are like Silicon Valley; not all industries are like biotechnology or software; and not all universities are like Stanford. University leaders responsible for the economic development mission need to understand the particular circumstances and needs of local industries, as well as the strengths and weaknesses of their own institutions. These leaders need to understand the pathways along which local industries are developing and the innovation processes that are associated with those pathways. And they should seek to align the university's contributions to local economic development with what is actually happening in the local economy. The outcome will not be the same for every university. Indeed, it will likely be different in different parts of the same university to the degree that different industries are present in the region.

This discussion points to the need for a strategic awareness of local industrial developments going well beyond the norm even at universities with a strong tradition of working with industry. It further suggests the need for a strategic approach to the economic development role within the university itself. However, universities, with their decentralised management structure and multiple stakeholders, each with different and often conflicting goals, lack the organisational coherence of a business enterprise. Precisely because of this, however, it is important for university administrators to be clear about the goals they are seeking in the economic domain and how they intend to achieve them. It is equally important for these administrators to be clear about what they do *not* seek to achieve. In this domain, as in others, universities cannot be all things to all people, and a failure to formulate and clearly articulate an institutional strategy for economic development risks underperformance in this domain, interference with other institutional goals, increased conflict within the university, and disappointed external constituencies. Finally, an economic development strategy is important because universities compete with each other for faculty, students and research funds. Competing successfully depends partly on being able to do the same thing that rivals do (only better), and partly on being able to differentiate oneself from one's rivals. A well-designed, effectively implemented strategy for engaging with the local economy can contribute to both goals (Lester 2005).

The conclusion of the Lester (2005) study is that local economies thrive to the degree that local firms succeed in adapting to new market and technological opportunities through innovation in products, services and production processes. This innovation performance hinges in turn on the ability of local firms either to develop new technological and market knowledge themselves or to acquire it from elsewhere and then apply it productively. This study sheds considerable light on how universities can strengthen these local innovative capabilities:

- **Universities have multiple ways to contribute to local innovation processes directly.** The possibilities are not limited to patenting and licensing discoveries made in university laboratories. In addition to their own discoveries, universities can help to attract new knowledge resources from elsewhere. They can help to (a) adapt knowledge originating elsewhere to local conditions; (b) integrate previously separate areas of technological activity in the region; and (c) unlock and redirect knowledge that is already present in the region but not being put to productive use.
- **In most cases, the indirect support provided by universities for local innovation processes is likely to be more important than their direct contributions to local industry problem-solving.** The most important of these indirect contributions is education. But a university can also play an important role as a public space for ongoing conversations involving local industry practitioners about the future direction of technologies, markets and local industrial development. This public space can take many forms, including meetings, conferences, industrial liaison programmes, standard forums, entrepreneur/investor forums, visiting committee discussions of departmental curricula, and so on. The conversations between university and industry that occur in these spaces are rarely about solving specific technical or commercial problems; but they often generate ideas that later become the focus of problem-solving both in industry and in universities. The importance of the public space role of the university and its contribution to local innovation performance is frequently underestimated.
- **The conditions, practices, and attitudes that lead to successful technology take-up and application in local industries depend on the specific characteristics of the industry and its development pathway**. These studies make clear that industry upgrading, industry diversification, industry importation and industry creation are each associated with different local patterns of technology take-up and application. More specifically, for each type of transition a distinct pattern of university participation was observed in the local innovation system.
- **Universities should approach their role in local innovation processes strategically.** This means developing an understanding of the particular circumstances and needs of local industries and the strengths and weaknesses of their own institutions; and it means seeking a fit between local industry needs and internal university capabilities. Universities should discard the one-size-fits-all approach to technology transfer in favour of a more comprehensive, differentiated view of the university's role in local economic development.
- **A strategic approach to the local economic development role is compatible with the pursuit of excellence in the university's traditional primary missions in education and**

> **research.** In fact, success in these primary missions is a necessary condition for contributing effectively to innovation and growth in the local economy. The fear that these missions will somehow be harmed is not a good reason for universities not to embrace their role in local innovation processes.

In each of these cases, universities played different roles and provided varying levels of support. Usually transformation was driven by an individual firm and its interest in remaining competitive. Ideas on how best to compete were gleaned not only from the local university, but also from suppliers, competitors and internal sources. The sources of university support generally fell into four categories. Often the university was instrumental in providing or enhancing local human capital at either the undergraduate, masters, doctoral, mid-career or executive level. Universities also increased the local capacity for problem-solving. This can include everything from contract research, faculty consulting and technology licensing to setting up incubators and providing specialised equipment or instruments. An often overlooked function of universities is that they simply provide public space and host meetings and forums that can bring investors, companies and academics together. Finally, universities can be a source of codified knowledge, providing comprehensive references on technical standards, patents and other criteria.

As Lester (2005) points out, one of the key findings of this project is that no single strategy of university engagement is the panacea for aiding economic growth everywhere. What works is largely determined by the type of industrial transformation that is being attempted. For example, in the case of the creation of a new industry, the key activities support various aspects of new business transformation. The university is often a broker between the university's researchers and local entrepreneurs. In the case of transplanted industries, a key university function is producing human resources for the firm and often creating a curriculum and a continuing education programme that supports the firm's growth. For cases involving the diversification of existing firms, the university can often serve to link firms together, allowing them to consider how the technology might be applied to their businesses. When local firms are attempting to upgrade their technology base, universities can often serve as problem-solvers, offering consulting and contract research opportunities.

Chapter 5
University–industry linkages

Chapter 4 described the relationship between universities, innovation and local economic development through a detailed description of the aims, findings and conclusions of MIT'S Local Innovation Systems Project. This section continues on the theme of university-industry linkages through focusing more broadly on the respective roles of government, firms and universities.

The comparative advantage of certain universities to complement teaching with research is behind the gathering interest in university–industry linkages as a vehicle for supporting, if not accelerating, technology development. Virtually every industrial country is moving to make university-industry links a centrepiece of its innovation systems, and the notion of a triple helix – representing the symbiotic relations linking the government, universities and the business community – has acquired wide currency (Etzkowitz & Leydesdorff 1997; 2000; Etzkowitz *et al.* 2000).

Also important is the speed with which industrialising countries (such as China and India, which are constructing innovation systems) have embraced technology as the key to development and, with it, the utility of research-oriented universities as a means of augmenting the innovation capability of the economy (Sigurdson 2005). The emergence of this view of the role that universities are now expected to play is at odds with the nature of the achievement of even the most entrepreneurial universities in the USA. As indicated in the previous section, universities contribute relatively little to patenting, licensing and spin-offs, except in the life sciences. Most firms still attach more importance to informal contacts with universities that relate to the recruitment of graduates, internships and consulting.

According to Yusuf (2007:8), university–industry linkages as an 'idea and even as a major strand of innovation strategy could remain far removed from universities as drivers of growth unless a number of major policy steps are implemented'. Only some of them are policies of the central government. In a world where globalisation and localisation are occurring in tandem, three other players share almost equal responsibility for making policies and carrying them through. They are the universities themselves, sub-national governments and business firms. A national innovation system in which all these policies could effectively be calibrated and coordinated would be ideal, but inevitably difficult to implement (Yusuf 2007).

In many instances, universities are not ready to take on additional roles. The objectives and expectations of individual participants differ and diverge, and tried and tested policy tools are few. Added to this, the globalisation of research spurred by multinational corporations and the use of information technology encourage firms to look beyond their national boundaries (Carlsson 2006). Just as researchers are much readier to collaborate with colleagues from other institutions throughout the world, companies are seeking expertise in technology much more widely, forcing even universities in the Netherlands and Switzerland with a track record in the development of technology to worry about their competitiveness (see also Carlsson 2006; Friedman 2006; Kim *et al.* 2006).

Universities are being viewed as central to the nurturing of technology in all countries that are serious about strengthening their national innovation systems. Ultimately, most of the technological advances that have economic consequences can be traced indirectly or directly to universities, either through the training provided, knowledge spill-overs, or the actual research conducted or through university-industry linkages that enabled firms and academics to collaborate in the development of technologies.

As stated previously, the output of technologies from universities as measured by patents is relatively small even in Japan and the USA, although universities account for the majority of papers published in refereed scientific journals. The case is the same in European countries, and to some it suggests the potential for more technology development by universities. Others claim that the division of labour, whereby universities educate students and university-based researchers add to the storehouse of knowledge through their publications, is a good one. It keeps the focus on teaching, and basic research largely complements. According to this philosophy practised by leading universities such as Johns Hopkins, by being drawn into the crafting of commercialisable technologies and into links with the business sector, the university is likely to see its primary role diluted, and the quality of its education could suffer. Those arguing on such lines can also point to the great advances in technology during recent decades that suggest no fundamental changes in the role of universities are called for.

But the consensual view that times have changed is gaining ground. With the USA and a few European countries in the lead, national governments have begun applying with greater force a number of policies to promote research in universities and to encourage university–industry linkages. In East Asia, the governments of Japan, China and Singapore are also broadening and intensifying their efforts (Yusuf 2007).

National governments initially set the stage for the emergence of university–industry linkages through their higher education and innovation strategies. Those strategies determine how much is spent on tertiary education; how it is distributed across institutions; what kinds of disciplines are emphasised; what student quotas exist, if any; how much autonomy teaching institutions enjoy; what financing arrangements they have; and what kind of competition exists among them. Each strategy has a bearing on the likelihood and nature of university–industry linkages. In particular, the heterogeneity among tertiary institutions, the competition among them, and their autonomy with respect to policies and benefits are crucial; and such elements largely explain the success of universities in the USA (Yusuf 2007).

The push towards research and its commercialisation in the USA, Europe, Japan and China has acquired greater force because governments are trimming their contributions to university budgets and requiring them to supplement their earnings from the fruits of their research – whether through knowledge transfer, spin-offs or equity stakes in start-ups. By supporting competition between public and private universities, the state has also increased the pressure on once-protected state universities, as in Japan and Singapore, to bid for students and faculty on the basis of their reputations not only as teaching institutions but also as centres of research. This strategy complements pressures arising from globalisation. In the process, public universities are gaining more autonomy, which private universities have always enjoyed. This freedom opens opportunities for a more aggressive pursuit of reforms to attract better students, to expand R&D, to explore new sources of financing, and to acquire entrepreneurship skills. For universities, most of which have no tradition of entrepreneurship and limited managerial capacity, these additional responsibilities entail learning corporate skills, providing new incentives and introducing new courses.

As previously stated, a number of countries have made the development and patenting of technologies, as well as the licensing of their use, attractive for university researchers by granting them the intellectual property rights over scientific findings arrived at with the use of public funds. Where the patenting system functions effectively – that is, where the costs of applying for and maintaining a patent are affordable, turnaround is reasonably fast, and intellectual property rights are given a decent degree of protection by the courts, again at a cost that the bulk of patentees can manage – the incentives to push scientific research toward patentable discoveries that can have a commercial future has increased. Although the Bayh-Dole Act[3] was not responsible for the quickening of innovation, it certainly did stimulate patenting and paved the way to greater commercialization (Sampat 2006).

According to Yusuf (2007), national governments can further influence the commercial orientation of universities by developing science parks in the vicinity of universities, often with the participation of local developers, and by spurring university spin-offs and start-ups with university connections directly through their policies on venture capital and more indirectly through their rules governing capital markets and the launching of initial public offerings.

As firms have moved to moderate their own basic research and focus their own efforts, they have come to rely more on university-based researchers in emerging fields where interdisciplinary expertise is required, such as nanotechnology. National governments, as in China, are also attempting to multiply university–industry linkages by measuring the performance of universities with reference to the number of spin-offs or start-ups, among other indicators. Where this strategy works, many of the emerging firms are likely to maintain their links with the university, particularly in fields such as biotechnology that are more dependent on advances in basic science and on tacit scientific knowledge.

Yusuf (2007) further shows that in many countries, the policies of the central government with respect to university–industry linkages are complemented by those of the sub-national authorities, whether provincial, county or municipal. In Brazil, Canada, China and the USA, for example, this decentralisation sets the stage for competition to attract and retain industries – especially those that generate numerous localised links, employment, exports and added value. Frequently the favoured industries are technology and skills intensive. For them, a research-oriented university with strong science and professional programmes can be a major attraction because it can be a source of both trained staff members and of knowledge spill-over. For example, researchers in the university can assist with the refinement of existing technologies and the development of new techniques.

What develops from such links depends on many factors, including the technology bias of the firms, their strategy with respect to technology, and their readiness to pursue innovation in an open manner by using local talent. The quality of university researchers, their ability to collaborate with firms, and university policies all determine outcomes. However, in a decentralised context, sub-national policies can affect the proliferation and the fruitfulness of university–industry linkages in two ways if governments come to view universities as sources of growth and as potential foci of industrial clusters. First, provincial and municipal policies concerning universities can affect the quality and orientation of research. Second, these policies can catalyse links and strengthen the incentives for university–industry linkages (Yusuf 2007).

Sub-national governments in Europe and the USA, as well as in Brazil, China, India and Japan, are using a mix of policies to cultivate university–industry linkages and convert universities into poles for growth. The policy options for creating links with second-tier provincial authorities are circumscribed by the depth of talent that can be mobilised by these universities in specific fields, their capacity to offer interdisciplinary breadth, and the globalisation of research. Moreover, the transaction costs for small and medium enterprises are such that their ability to engage universities is unlikely to change. Policies can contribute, however, to the university's reputation and quality remains an important starting point (Yusuf 2007).

The decision to establish links does however ultimately rest with the firms themselves. The recent experiences of industrial countries regarding the interaction between firms and universities are quite mixed, with no clear trends apparent.

Firms are more aware of the gains in competitiveness from innovation and are sensitive to the high returns from R&D. However, much of the R&D outlay is by large companies. Smaller companies invest little in research, although they do spend on testing, quality control and incremental innovation – whether done in-house, together with suppliers or (more often) outsourced to research labs and consultants. The larger firms have begun narrowing their own research efforts and making greater use of alliances and collaborative arrangements, taking over firms that have introduced new technologies, using outsourcing arrangements, and instituting university–industry linkages. Thus, in the interests of reducing costs, tapping a wider range of disciplines, canvassing a variety of technological options, and spurring multiple competing research initiatives, firms are moving towards open innovation practices. Relative to firms in the UK, American firms place more emphasis on an open innovation approach. One result of this emphasis that coincides with the efforts made by universities themselves is some increase in links between firms and university faculties (Yusuf 2007).

In Japan, companies prefer informal ties with universities. Corporate researchers co-author papers with university faculty members, spend time working at university laboratories, do joint projects with university researchers, and enter into consulting arrangements with university-based researchers. Typically, the university–industry linkages are with the leading large universities and research centres; firms are ready to seek out the best academic talent from across the country rather than limiting themselves to universities close to their own headquarters or research facilities (Yusuf 2007).

At the other extreme is the USA, where university–industry linkages cover the entire spectrum but formal contractual arrangements with universities are common, as are outsourcing of entire research projects to university laboratories, joint research agreements, and individual contracts with key researchers. Europe falls somewhere in the middle. In the Republic of Korea and India small firms have virtually no contact with universities as far as research is concerned, but they may seek help from individual researchers for the purpose of trouble-shooting. In those countries, links, mostly of a localised nature, are emerging between some of the larger companies in the technology sectors and elite universities. A similar tendency is materialising in China as a result of a determined push by governments to induce both universities and state enterprises to cooperate in developing technologies (Yusuf 2007).

So far, evidence from industrial countries indicates that the large multinational corporations are most likely to tap the research potential of universities. The best equipped to do so are multinational corporations that are actively seeking specific kinds of results that complement their own research. Multinational corporations banking on innovation to sustain competitiveness have the information, the finances, the organisational capacity to manage a multifaceted research programme, and the commitment to routinised innovation that can induce technology links with universities. But because multinational corporations increasingly have global reach and information on the research potential of universities and institutes, they are more likely to seek the most cost-effective and technologically fruitful arrangements and not to limit their search to institutions in their own countries or in proximity of their primary location. When overtures to universities by firms do not elicit positive responses, firms are likely to shop elsewhere. For example, Thai universities have allowed opportunities for university–industry linkages to slip away because of a lack of proactive measures, entrepreneurship, organisational skills and government support.

If the life sciences, nanotechnology and other fields whose development is paced by basic science, continue to flourish, the elite universities and research institutes may be better placed than most corporate laboratories. In fact, many biotechnology firms are spin-offs, were started by university researchers, or are based on the findings of research at a university with which they are frequently associated.

University policies

Although most universities in industrial and developing countries still have formal links with the business sector, the economic, technological and business contexts are changing, and with them the attitudes of university administrators. Many more universities, or at least researchers in tertiary institutions, will be trying harder to commercialise scientific discoveries and to connect with the business world, as is the case in China, Singapore and Taiwan (China).

Although generalisations are difficult, the underlying trend is towards greater autonomy for public universities and, overall, toward greater competition among universities for students, resources and star faculty members. This competition is rapidly acquiring a global dimension as students and academics become more mobile and perceive a wider range of options. In addition, universities, behaving a little like multinational corporations, are setting up satellite campuses in other countries and entering into partnerships, leveraging their brand and human capital (Yusuf 2007).

Many universities are also coming to realise that with recurrent expenditures mounting, student demographics changing, and salaries demanded by able teachers and researchers on the rise, a pure teaching function might prove to be unsustainable. In fact, one of the biggest problems confronting universities vying for the best research talent in Europe and Japan is that university salaries often are below salaries for similar jobs in industry. Closer relations with the business sector may be unavoidable.

Where feasible, academics have attempted to supplement their salaries with consulting. This situation is even true in industrialising countries such as Thailand and Vietnam, where salaries are low and consulting is almost a necessity. When teaching and administrative responsibilities permit, more schools have encouraged faculty members to consult and bid for research grants. In fact, the performance and worth of an academic in some institutions is being measured with reference not just to teaching skills and publications, but also to earnings from consulting and resources mobilised from external sources.

Some universities have attempted to promote and capitalise on in-house research by setting up technology licensing offices to patent findings and solicit license fees and royalties. A small number of universities, such as Stanford and MIT, as well as the California state universities, reap a few million dollars per year from this effort. For others, the earnings often do not cover costs.

Many large elite universities have set up incubators to nurture firms that can be spun off, sometimes with the help of venture capital provided by the university or with the help of university connections. Except in quite rare cases, few of these ventures provide the university with large returns on invested capital, but some do, and spin-offs from Tsinghua University and Peking University in Beijing are a major source of revenues for their parent organisations (Yusuf 2007).

An adjacent science park generally requires the backing of sub-national or national governments; however, scores of universities throughout the industrial world are helping to develop industrial clusters in such customised parks. In India alone, well over a dozen software parks operate in the vicinity of the nation's premier technology institutes. The necessary conditions for growing a cluster are now reasonably well codified. Singapore, for instance, is attempting to fulfill all of these conditions (Yusuf & Nabeshima 2006), but the necessary conditions to achieve success are elusive. So cluster development is a risky business, and many of the science parks are financial failures. Numerous examples of such failed attempts exist in China.

These initiatives reflect only some of the policies being pursued by universities to build bridges to the business sector. It must be emphasised that the term 'entrepreneurial research university' applies so far to a select few in any country. Size, location and circumstances circumscribe the role of most tertiary-level institutions. The extent to which university–industry linkages proliferate and what their effect will be on technological capability will depend in large part on the policies adopted by the four principal players: national government, subnational governments, firms and universities.

Public officials and universities the world over have been greatly influenced by the experience and example of Stanford, MIT and the University of California and San Diego; and many economies in Asia and Europe are attempting to replicate those examples – notably China, Malaysia, Singapore, and Taiwan (China). Industrial countries are coming to view universities as vehicles for accelerating technological advance to enable them to stay ahead of competing middle-income countries. Late starters view research-oriented universities as vehicles for catching up technologically with the frontrunners.

As Yusuf (2007) explains, two 'imponderables' exist here. One is whether, through links with the business sector, some universities can actually be converted into engines for promoting technological change without being seriously deflected from their primary missions. It is an open question also whether their direct contribution to technology development and innovation, which has been limited thus far, can be appreciably raised.

Second, if measures to significantly raise the level of R&D in universities can be made to work, this accomplishment need not be matched by demand from firms, and it might not lead to spin-offs from the university or to start-ups. The larger firms that are most partial to university research may not have the appetite for more, and smaller and medium-sized firms might continue to shy away in the absence of effective intermediary institutions that serve as bridges between universities and firms (Yusuf 2007).

Southern Africa

Little was known about the nature and scale of interaction between universities in southern Africa and private firms until the study undertaken by Kruss and Petersen (2008). This study shows, for example, that 58% of Southern African Development Community (SADC) public higher education institutions can provide examples of collaborative community development programmes; 41% examples of collaborative projects with business and industry; and 59% of them have plans in place for collaboration with industry.

The existence of all forms of university–firm interaction is low, but those that are common include the education of work-ready students and consultancy. Two potentially critical areas of interaction – software development and agricultural services – were ranked much lower in importance.

In terms of innovation, the picture is not encouraging with 60% of the sample reporting no involvement with technology transfer, 40% not being involved with research and development for firm innovation, and 52% not being involved in software development or design.

Channels of interaction with firms that SADC universities rate as very or moderately important include: public conferences and meetings, recent graduates hired by firms, publications and reports in the public domain, individual consultancy, research and development cooperative projects, and informal information exchange. Channels regarded as less important are those related to the new commercialisation role of universities in the developed world: patents, technology incubators, spin-off firms, licensed technology, and science/technology parks.

Three groups of SADC universities were distinguished based on the scale of their interaction with firms:

1. **Relatively new, medium to large universities that have a moderate scale of firm interaction:** Eduardo Mondlane (Mozambique), National University of Science and Technology (Zimbabwe), Open University (Tanzania), and University of Technology (Mauritius).
2. **Established, large and more traditional universities and very new, small universities with a technology/entrepreneurial orientation, both of which have small-scale interaction with firms:** Dar es Salaam, Mauritius, Universite de Toliara (Madagascar), Harare Institute of Technology, University of Malawi, Midlands State University (Zimbabwe), and University of Botswana.
3. **Small, established, new and technology-oriented universities that have isolated incidences of interaction:** Mzuzu University (Malawi), University of Swaziland, Universite Antananarivo (Madagascar), Universite D'Antsiranana (Madagascar), Lurio University (Mozambique), Muhimbili University of Health and Allied Sciences (Tanzania), Zimbabwe Open University, Universite de Goma (DRC), and Universite of Fianarantsoa (Madagascar).

According to Kruss and Petersen (2008), the understanding of the role of universities in facilitating technological upgrading in sub-Saharan Africa has been largely speculative, ranging from the ideal to the anecdotal.

For South Africa, Kruss (2005a; 2005b) has defined the forms of university-firm interaction. She notes that traditional forms of interaction continue, including donations and student sponsorship. However, the dominant forms of interaction are consultancies and contracts. In addition, there is small but increasing evidence of new entrepreneurial forms of interaction such as commercialisation, in which higher education researchers attempt to commercialise intellectual work in the form of spin-off companies or in collaboration with an existing company.

Section 6

Universities and public research institutions as drivers of economic development – the East Asian experience

The East Asian experience with catch-up industrial development, achieved over the half-century from 1950 to 2000, stands as one of the great episodes of modern economic development. Mathews and Hu (2007) show that the mechanisms that were used to steer the development of industries and markets involved states and state-sponsored institutions working closely with private-sector firms and markets.

Increasingly, the role of technological capacity development is coming to be viewed as central to the industrialising effort – and as the driving factor in East Asian success over the past half century. In this setting, universities and public research institutes (PRIs) are two of the key institutions that shape economic development (Mathews & Hu 2007).

Universities played a very special role in East Asian development – not as drivers of innovation, as commonly viewed in the West, but as shapers of human capital formation. During the second half of the 20th century, universities were at the forefront in training generations of highly skilled, technologically sophisticated graduates, who could be employed successfully by domestic firms seeking to enter global industries, by multinational corporations, and not least by the institutions steering the economy's industrial development. The foundation for this role played by the universities and newly established polytechnics was the steadily rising rate of adult literacy and numeracy, which by the year 2000 was approaching 100% in countries such as the Republic of Korea – among the highest in the world.

By contrast, the public research institutions, such as the Industrial Technology Research Institute (ITRI) in Taiwan (China) and the South Korean Development Institute played a role of technology capture agencies and technology diffusion managers, going abroad to seek the technologies needed by local firms and building capabilities in those technologies which the PRIs passed across to the private sector as rapidly as possible. These institutes worked closely with domestic firms (even establishing firms where they were lacking), catalysing their capacities to become technologically sophisticated players in their own right. PRIs drove the development of national innovative capacity in East Asian economies as they gradually moved from catching up and imitation to fast-follower innovation.

In the opening years of the 21st century, both universities and PRIs in East Asia are undergoing further transformation as the effects of Bayh-Dole policies are felt. Thus, economies as diverse as Hong Kong (China), Singapore and Taiwan (China) are pursuing similar strategies as universities and PRIs are encouraged to keep abreast of new technologies by patenting, by publishing in scientific journals, and by promoting spin-off enterprises. Although the results are still rudimentary at this stage, they point to a trend that could become significant in the near future, particularly as it is adopted and expanded in China and India.

The latecomer development model

From 1950 to 2000, the East Asian economies fashioned a uniquely successful industrial development model in which the focus was clearly on science and technology as the primary productive forces. The idea was that these economies, as latecomers, could focus their industrial development on targeted catch-up efforts, industry by industry and technology by technology, drawing on the knowledge accumulated in the leading countries. The model was developed first in Japan, then rapidly adopted in Korea and Taiwan (China), and later taken up by Singapore and to some extent elsewhere in South-East Asia.

This model was a 20th century version of the catch-up strategies that had been perfected in the 19th century by European latecomer nations, particularly Germany and by the USA – as described so effectively by Gerschenkron (1962; 1970).

The Gerschenkronian approach invites concentration on the issues that matter most; namely, the building of new institutions and the pursuit of fresh strategies, depending on the situation when a country is attempting (or reattempting) its development push. Which institutions are most relevant in any given country or at any given time will vary. But the strategic use of institutions to overcome latecomer disadvantages can have a significant effect on development. With each successive entry by a latecomer country into the ranks of the industrial world, the barriers to entry change, and a different situation is bequeathed to those coming after. They must devise fresh strategies to get around the newly created barriers. Institutions and practices must then be discarded as soon as they have outlived their utility, so as to avoid the trap of allowing firms to become dependent on them.

Latecomer firms, like latecomer nations, exploit their late arrival to tap into advanced technologies, rather than replicating the entire preceding trajectory. They can accelerate their uptake and learning efforts through collaborative processes and the help of state agencies, thereby avoiding some of the organisational inertia that holds back their more established competitors. They thus develop strategy on the basis of the possibilities inherent in their latecomer status. The strategic goal of the latecomer is clear: catch up with the advanced firms and move as quickly as possible from imitation to innovation. This strategy has never been put into practice more effectively than by the East Asian economies in their half century of accelerated development.

The process of industrial development in East Asia may be viewed as one involving a series of choices, all conceived as strategic exercises in collective entrepreneurship. Entrepreneurship provides the appropriate framework for assessing development strategy, with an appropriate balance between the collective and individual facets of development. Latecomers seek to compensate for their shortcomings in technology and market sophistication through institutional innovation, under the guidance of development agencies, creating institutional solutions as problems are encountered. Examples include using export processing zones to promote foreign direct investment in manufacturing activities and using public research institutions, such as ITRI in Taiwan (China), to act as technology leveragers and builders of national technological competences. Repeated applications of the processes of linking with commercial structures and leveraging knowledge from such sources teach latecomers to practise development as a process of collective entrepreneurship.

The role of universities and PRIs in industrial development in East Asia, 1950–2000

In keeping with the latecomer strategy, the East Asian economies never saw universities as agents of innovation – at least not during their half-century of accelerated catching up. Instead, they saw universities as agents of human capital formation. Universities were viewed as advanced training institutions and were built and established at an enormous rate. In Taiwan (China), for example, the country's technical education superstructure expanded rapidly in parallel with other efforts to tap the knowledge of the advanced countries. In 1952, there were four universities and four junior colleges, with total enrolment of just over 10 000 students. By 1989, this infrastructure had expanded to 42 universities and 75 polytechnics or colleges – a massive expansion in just over three decades.

Likewise, the Republic of Korea poured resources into the tertiary sector; so much so that by the turn of the century its levels of enrolment were higher than those of the USA, which had been the leader in human capital formation for the preceding century. Also, important is the point that latecomers that specialise in science and engineering first degrees stand the best chance of raising their per capita GDP.

The role of public research institutions

Although universities played the role of human capital formation institutions, the actual tasks of leveraging technology and diffusing it to the private sector were allocated to public research institutions. They emerged as the central and defining institutions of the East Asian catch-up experience.

ITRI of Taiwan (China), founded in 1973, serves as the benchmark for such technology capture and diffusion institutions. It was the prime agency in building pilot versions of new technologies before they were taken up by the private sector and it did not engage in fundamental scientific research – on the contrary, it was concerned strictly with identifying and evaluating available technologies. ITRI provided shared R&D services for existing and emerging industries, precisely as the R&D department of a large, established company does. Technologies already being used are tested to see how they can be improved; technologies used by rivals and competitors are reconstructed and analysed; potential substitute technologies are evaluated. These are the activities of an R&D department in a large firm such as IBM or Toshiba, and they are the means by which the company builds its technological absorptive capacity. But in a latecomer economy, few firms can afford such a department. If they can, they can make the technical evaluations of new projects for themselves or they can hire expensive consultants to do so for them. Although most firms have no means to benefit from such services, they are needed to enable the economy to capture its potential latecomer advantages. ITRI was the general institution that filled that gap in Taiwan (China).

As documented in the expanding literature, universities and PRIs such as ITRI may be seen as contributing not only to their own innovation results but more fundamentally to the economy's innovative capacity – that is, capacity to sustain and enhance innovation as the industrial structure becomes more knowledge based. Recent reforms in East Asian economies such as Hong Kong (China), Singapore and Taiwan (China) are calculated to promote academic innovation through institutional and organisational reforms, and thus to drive the transition from manufacturing "fast follower" to innovation-based technology developer.

Innovative capacity is the basic driving force behind economic performance; it provides a measure of the institutional structures and support systems that sustain innovative capacity. National innovative capacity may be broadly defined as the institutional potential of a country to sustain innovation. Thus the capacity to innovate is concerned with no single aspect of innovation performance, but rather with the sources of its sustainability.

The emerging role of universities and public research institutions in East Asia

The story in East Asia may be contextualised for the 21st century by focusing on the new policies being pursued, most of which were inspired by the Bayh-Dole Act. Recognising the profound effect that the act has had in the USA, other countries – particularly those in East Asia – have been quick to follow suit. Korea, Singapore and Taiwan (China), and now China and India, are all promoting their universities and public research institutions as champions of a new style of innovation driven by patenting, publishing in key scientific and technical journals, and spinning off new enterprises. But this institutional innovation is a latecomer; the new entrepreneurial activities remain targeted to key industries and technologies.

The generalisability of the East Asian experience

Of all the countries in the developing world today, China and, to some extent, India, appear to be the most successful at applying the lessons of technology leverage. They are drawing on the accumulated stock of knowledge of the industrial world and applying it in accelerated fashion to their development agendas. China, in particular, appears to have studied the model of Taiwan (China) very closely and, despite political differences, is applying it very successfully to its own case in sector after sector.

The principal difference between the world faced by the East Asian countries in the 1960s and the world faced today by latecomers such as Latin American or Central Asian countries is the tight regulation by the WTO and its associated instruments such as the Trade-Related aspects of Intellectual Property Rights (TRIPS) agreement and the Trade-Related Investment Measures (TRIMS) agreement, which deals with investment-related policies such as local content regulation. Discussions on the prospects for developing countries centre on the barriers created by such World Trade Organisation (WTO) instruments (Mathews & Hu 2007).

Nevertheless, the experience of East Asian economies in building technological capacities that enabled them to catch up with industrial countries – through technology capture and diffusion programmes, programmes to nurture new firms, and programmes focused on seeding new industry – remains a standard for what can be achieved by latecomer countries without breaching any WTO, TRIPS or TRIMS protocols. As those economies catch up and approach the technological frontier alongside the industrial countries, they can modify the institutional parameters of their universities and PRIs to enable them to play a more entrepreneurial role in driving new technological developments. It is a case of taking one step at a time and not attempting to run (with a Silicon Valley-style model) before learning how to walk (with an imitation-driven innovation system). This is the enduring lesson of the latecomer effect in industrial development (Mathews & Hu 2007).

Endnotes

1. Note that in this paper, the terms 'higher education' and 'tertiary education' are used interchangeably, although the latter is often used more broadly to describe universities and other post-secondary institutions.
2. The 'knowledge economy' generally refers to the central role of knowledge and innovation in economic growth and broader development.
3. The Bayh-Dole Act of 1980, promulgated in the USA, set a new benchmark for universities and PRIs around the world. The basic effect of the Act was to provide an incentive for universities and PRIs in the USA to take possession of IPR.

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