

Innovation, Sustainability, Development: A New

MANIFESTO



Innovation Capabilities and Directions of Development

Martin Bell

Capabilities





About this paper

The central challenge in the original Sussex Manifesto centred on massively increasing the developing countries' scientific and technological capabilities for creating new knowledge and shaping the technologies they used. It also stressed the need for radical change in the national and international contexts within which those capabilities would be accumulated and used. This paper reviews those ideas in their intellectual context of the late-1960s and early-1970s. With reference to industrial development broadly defined, it then outlines how our understanding about the accumulation of such innovation capabilities has changed since the 1960s, highlighting their role in shaping the direction of innovation and not just its rate. It notes, however, that other influential perspectives attach little importance to the role of industrial innovation capabilities in developing countries. On the one hand, they are seen as irrelevant when technologies from advanced economies can be acquired and absorbed. On the other, their most important components are often omitted from national S&T strategies that strengthen only centralised, public R&D capabilities. The paper therefore emphasises the importance of policies that seek to develop two kinds of complementarity: between widely dispersed local innovation capabilities and (a) technology imports, and (b) centralised R&D activities.

About the author

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About the Manifesto project

In 1970 a radical document called The Sussex Manifesto helped shape modern thinking on science and technology for development. Forty years on, we live in a highly globalised, interconnected and yet privatised world. We have witnessed unprecedented advances in science and technology, the rise of Asia and ever-shifting patterns of inequality. What kind of science and technology for development Manifesto is needed for today's world? The STEPS Centre is creating a new manifesto with one of the authors of the original, Professor Geoff Oldham. Seeking to bring cutting-edge ideas and some Southern perspectives to current policy, the New Manifesto will recommend new ways of linking science and innovation to development for a more sustainable, equitable and resilient future.

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The STEPS Centre (Social, Technological and Environmental Pathways to Sustainability) is an interdisciplinary global research and policy engagement hub that unites development studies with science and technology studies. Based at the Institute of Development Studies and SPRU Science and Technology Policy Research at the University of Sussex, with partners in Africa, Asia and Latin America, we are funded by the Economic and Social Research Council.

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1. INTRODUCTION

This background paper for the STEPS Manifesto Project focuses on a central strand of argument in the 'Sussex Manifesto'¹ – a 1970 report commissioned by the United Nations Advisory Committee on the Application of Science and Technology to Development (ACAST).² The selective focus of the paper concentrates on the core challenge of the Manifesto - a call to transform the efforts then being made to strengthen scientific and technological (S&T) capabilities in developing countries. The underlying aim of this challenge was clear: developing countries should not simply be choosers and users of 'ready-made' technologies they acquired from advanced economies; they should also be adapters, improvers and creators of the technologies they used in their development.

From the outset, [...] we reject the idea that the existing international division of labour in science is adequate for development. It provides no basis whatsoever for development; amongst other things, the less developed countries must have an *indigenous scientific capability*. (Singer et al 1970: paragraph 18, emphasis added)³

In other words its core argument was that developing countries should become increasingly significant innovators.⁴ Consequently, both they and the advanced countries should increase the resources they allocate to building what were then seen as the necessary capabilities for innovation *in* developing countries. The magnitude of this Manifesto challenge was striking in three main ways.

- i. Very ambitious targets for the growth of scientific and technological capability in developing countries were set out. These were couched in terms of R&D expenditure that should grow over the 1970s from 0.2 percent of GDP to about 0.5 per cent. This implied an increase of the developing countries' share of total global research and development (R&D) from about 2 per cent to around 4-5 per cent.
- ii. The Manifesto stressed that R&D capabilities constituted only a narrow segment of the full array of scientific and technological capabilities needed, and 'many times this amount' would be involved if the full array were taken into account.
- iii. The rapid growth in capabilities should be facilitated by the transfer of financial and technical assistance from advanced countries that would be equivalent to 0.05 of those countries' GNP - about 5 per cent of total aid.⁵

¹ A wider review of all the main recommendations and arguments in the Manifesto is provided in another background paper: Ely and Bell (2009)

² Singer et al (1970). The report was prepared by a group of scholars associated with the University of Sussex (from the Institute of Development Studies, located on the campus of the university, and from the Science Policy Research Unit, a research institute of the university). Having been described pejoratively in the UN General Assembly as 'a manifesto', it later became known as: *The Sussex Manifesto*. It was reprinted as 'The Sussex Manifesto: Science and Technology to Developing Countries during the Second Development Decade', IDS Reprints 101.

³ Subsequent references of this type will be abbreviated to: Singer et al 1970: para 'n'

⁴ Though the Manifesto rarely used the term 'innovation'. With respect to the idea of innovation as a process, it mainly refers to activities like 'science' or 'science and technology' (more or less interchangeably) as its main components, and innovations were seen as the main 'outputs' of those activities – as in: '...the ability to use transferred technology as the basis of further innovations [...] depends entirely on local scientific capability' (Singer et al 1970: para 4)

⁵ It was also recognised that the suggested effort to build innovative capabilities *in* developing countries would on its own be inadequate. Given the huge weight of global innovative activity that was undertaken in the advanced countries (98 per cent of the global total), the composition of the global stock of technology was becoming 'less and less directly suitable for use by developing countries'. So a distinct fraction of innovative activity in advanced countries (equivalent to 5 per cent of their total R&D) should be 'redirected' towards creating technology with characteristics that would be important in developing countries.

This was one of the earliest major calls to shift the emphasis of debate and action about science and technology in developing countries so substantially towards the development of those countries' own innovation capabilities – in contrast to prevailing emphases on various scientific and technological activities in advanced countries for developing countries and the international transfer of technology. This paper asks whether that challenge still has the significance it did forty years ago? If so, how do the broad approaches to meeting it need to alter in the light of changes since then in what we understand about innovation capabilities in developing countries, as well as changes in the conditions within which such capabilities must be created and used?

The rest of the paper is organised as follows. I outline in Section 2 selected features of the perspectives and scope that frame the discussion in the rest of the paper. Then I return in Section 3 to the original Manifesto and the immediately associated academic discourse that it reflected. I highlight the centrality of concerns at that time about the orientation (or direction)⁶ of innovative activity, and within that the primary focus on questions about whether and how that direction of innovation might be shifted in order to alter access to employment and income and hence change the prevailing patterns of poverty and inequality.

Section 4 traces the subsequent development of ideas about innovation capabilities in developing countries. This has involved two contrasting trends since the late 1960s. On the one hand, important features of the Manifesto perspective have been attenuated or lost sight of altogether - in particular, (i) issues about the direction of innovation, especially with respect to income distribution and poverty, and (ii) understanding about the importance of the political and institutional context of innovation. On the other hand, several aspects of the Manifesto perspective have been extended and further developed in important ways that have deepened understanding about the nature of innovation capabilities and how they are created and accumulated in developing countries. In particular, attention has been drawn to the central importance of capabilities other than R&D capabilities, and also to the importance of these being deeply and pervasively embedded in the production sectors of the economy.

But I argue in Section 5 that little of this understanding about innovation capabilities has been drawn into two important areas of 'mainstream' development analysis and policy. First, as reflected in several major reports on growth and development in recent years, a standard/dominant view dismisses the idea of building innovation capabilities as virtually irrelevant in developing countries until they reach the upper tiers of Middle Income countries. Second, despite that view, developing country governments have typically established broad policies and strategies for strengthening scientific, technological and innovation capabilities but, as in the 1970s, the kinds of capabilities envisaged still consist almost entirely of centralised R&D capabilities. Little or no attention is given to the importance of dispersed innovative capabilities that are deeply and pervasively embedded in production activities.

In other words, the academic community that has undertaken research about innovation and innovation capabilities in developing countries over the 40 years since the Manifesto has not communicated effectively with the communities of scholars, politicians and bureaucrats who have contributed to policy prescription over recent years in two key areas: (i) broad policy approaches to secure growth and development, and (ii) mainstream formulations of policy for science, technology and innovation in a large block of developing countries.

I conclude in Section 6 by exploring how changes in the practicalities of policy in this area interact with, and may be constrained by, underlying ideas about the key characteristics of innovation and

⁶ In this context, the terms 'orientation' and 'direction' were used almost interchangeably at the time (as were 'innovation', 'technical change' and 'technological change'). I will also use 'direction' and 'orientation' interchangeably in the rest of the paper – though this may not be totally consistent with the use of those terms in other STEPS background papers – e.g. Ely and Bell (2009).

innovation capabilities. Politics, in the sense of structures of power, interest and influence, may also constrain changes in both policy practicalities and the development of ideas, or at least their acceptance in the main policy discourse.

2. CLARIFICATION OF SCOPE AND KEY PERSPECTIVES

It is probably useful to clarify at this stage three aspects of the scope and perspectives that frame the discussion in the rest of the paper, and then to summarise the main thrust of the argument in the paper.

SECTORAL SCOPE - INDUSTRY AND INFRASTRUCTURAL SERVICES

The paper is written primarily with reference to the main area of my own experience - innovation in industry. It is important, however, to stress that the 'industrial' sector of the economy accounts for much more than, and should not be conflated with, the much narrower field of 'manufacturing'. The non-manufacturing segment of industry has three main components: the 'utility' industries (primarily concerned with supplying electricity, gas and water), (b) the mining industries (including petroleum) – often an especially large fraction of economic activity in smaller and poorer developing economies, and (c) the construction industry. In addition, some frameworks would now include in 'industry' at least two sectors that are normally classified as services: transport and communications - important 'infrastructure' industries alongside the 'utilities'.

The industrial sector, and especially its non-manufacturing component, has considerable importance in even the lowest income developing countries. This can be illustrated by Table 1 that shows the structure of GDP in three groups of economies (Least Developed, Low Income and Middle Income) in terms of three broad sectors: agriculture, services and industry – with industry disaggregated to show the share of manufacturing.

The usual cross-sectional difference in structure between economies at different income levels is evident. But particularly interesting is the change over time between 1999 and 2005 as the industry and agriculture components moved along converging paths in the Least Developed Countries (LDCs). The share of agriculture fell quite rapidly to account for much less than one-third, while the share of industry rose to account for almost the same fraction. Among all Low Income countries, those two paths crossed after 1999, with industry coming to account for a larger share than agriculture. Within industry, manufacturing in the LDCs accounted for less than half of value added in 1999 and, having experienced relatively slow growth, accounted for an even smaller share in 2005. In contrast, however, the non-manufacturing component of industry ('Other Industry' in Table 1) was the fastest growing segment of the economies of this group of countries over the 1999-2005 period.

Obviously, the scale of value added is not the sole indicator of sectoral importance. In particular, agriculture and 'informal' service activities account for a much larger share of employment than of GDP in Low Income Countries, especially in the LDCs, and they provide the current context for the livelihoods of a very large proportion of people with the lowest incomes and in deepest poverty. But, even with respect to the Least Developed Countries, the industry-orientation of this paper (including transport and communications) covers large and important areas of the economy.

TABLE 1. THE SECTORAL STRUCTURE OF THE LEAST DEVELOPED COUNTRIES

		Sector Value Added			
		As a Proportion of GDP			Change
		1999	2003	2005	
Least Developed Countries	Agriculture	34	29	28	- 18
	Industry, of which:	23	25	27	+ 18
	Manufacturing	11 (48%)	11 (44%)	11 (41%)	0
	Other Industry	12 (52%)	14 (56%)	16 (59%)	+33
	Services	42	46	45	+ 7
	All	100	100	100	+71
All Low Income Countries	Agriculture	28	24	22	- 21
	Industry, of which:	25	27	28	+ 12
	Manufacturing	14 (56%)	14 (52%)	15 (54%)	+ 7
	Other Industry	11 (44%)	13 (48%)	13 (46%)	+ 18
	Services	46	49	50	+ 9
	All	100	100	100	+72
Middle Income Countries	Agriculture	11	10		
	Industry, of which:	36	37		
	Manufacturing	19 (53%)	18 (49%)		
	Other Industry	17 (47%)	19 (51%)		
	Services	54	53		
	All	100	100		

Source: World Bank, World Development Indicators

However, the developmental role of industry is sometimes dismissed as being very limited because, it is argued, it inherently generates negligible 'trickle-down' effects contributing to poverty reduction. That perspective is not endorsed here – mainly for two reasons.

First, the poverty-reducing role of industrial growth is not limited to trickle down effects that reach poor people in their existing contexts of poverty. The expansion of industry also plays an important role in providing opportunities for poor people to move out of those contexts. In some situations that may not be able to absorb more than just the growth in the working-age population. But that is a reason to explore whether and how its role might be greater, not to dismiss its significance in the overall development agenda.

Second, since the trickle-down effects of industrial growth are not inherently fixed, the potential for such variability seems much greater than often presumed. To some extent this reflects differences *between* industries – for example, the basket-weaving or garment industries generate more jobs per invested \$ than mining industries. But beyond that, the magnitude of trickle down effects seems to vary quite widely *within* particular industries, varying with the intensity of efforts to make them occur. In some cases, for instance, these efforts may involve incremental, design-based product upgrading, or the development of entrepreneurial capabilities to introduce new products that create

extended 'backward linkages' from larger scale firms to small suppliers of 'new-to-market' goods and services⁷ – as illustrated in Box 1.

BOX 1. MAKING TRICKLE DOWN HAPPEN: TWO EXAMPLES

Basket-Weaving in Ghana

In the early-1990s the scale of the craft basket weaving industry in the Bolgatango region of Ghana was quite limited. But in the mid-1990s *specific efforts were made* to support the industry in improving its existing products, diversifying into new products and upgrading its production methods and marketing logistics. By 2002, the expanding basket exporting industry in Ghana provided employment for hundreds of rural basket weavers. (Action For Enterprise 2004).

Smelting Aluminium in Mozambique

The Mozal aluminium smelter in Mozambique started production in 2000. The immediate direct employment impact involved a limited number of jobs. The promoters of the project had initial expectations that significant indirect employment would be generated as opportunities emerged for small firms to supply the company. Only slowly was it realised that simply providing opportunities was not enough. *Specific steps were needed* to enhance small firms' entrepreneurial and innovative capabilities for starting new lines of business by entering supply contracts with the company. So, partly with funding from the International Finance Corporation (IFC), a project was set up to provide small firms with business and technical training, plus access to finance. Assessment by the company (BHP Billiton), the IFC and independent research suggests that a significant increase in local sourcing has been achieved. Also, the technology-centred scheme appears to have created a cumulative capability development process, providing a generically applicable capability that the small firms have used to secure supply contracts with other large firms in the area. (BHP Billiton 2005; IFC 2003; 2004; Warren-Rodriguez 2008).

THE ORIENTATION OF INNOVATION IN INDUSTRIAL DEVELOPMENT – THE PERSPECTIVE TAKEN HERE

In addition to stressing the importance of the *rate* of innovation in industry in developing countries, and hence the rates of output growth and rising efficiency in resource use, this paper is concerned with the *orientation* (or direction) of innovation in industry. In principle, the idea of orientation can embrace numerous different directions. Attention here centres on three: poverty reduction, sustainability and structural diversification.

(i) Poverty Reduction

This aspect of the developmental orientation of innovation encompasses two slightly different ideas. One is about the focus on *who* is involved – the kinds of people whose lives and activities change in the process of 'development'. I take a broad perspective on this. So, for example, poverty-reduction is not identified here only in a Millennium Development Goals (MDG) type sense, focusing on people living on less than a dollar a day, or people living among the 'bottom billion' trapped in the world's poorest countries. Orientations of innovation that improve the lives of people experiencing

⁷ The emphasis here on the role of specific actions as the 'source' of linkage-related trickle down effects is contrary to the views in an earlier generation of studies that saw such linkages and their effects as externalities that would arise more or less automatically from investment in the initial industrial activities themselves – as in Hirschman (1958). The view here is that such expectations of automaticity are misplaced.

those kinds of poverty obviously fall within the scope of the paper. But so also do others. For instance, when the proportion of people living on less than a dollar a day has been halved, and even when the remaining half has also moved over the dollar a day threshold, there remains the development challenge of reducing the numbers of people living on only slightly less miserable incomes of two or three dollars per day - or even five dollars and beyond.

I also take a broad perspective on a second view about the poverty-reducing orientation of innovation in industry. This is concerned with the *means, activities and processes* by which groups in society raise their incomes above a dollar a day and beyond. Very roughly, these can be seen as falling into two groups.

The first involves means and activities that are intended primarily to reduce poverty and improve the lives of people *in their existing contexts of poverty* – for instance, (i) improving agriculture in inherently marginal, stress-prone and risk-prone agricultural environments, or devising ways (e.g. novel irrigation methods) to reduce the incidence of stress and risk in those contexts, or (ii) improving health service provision in urban slum communities and devising schemes to improve sanitation and reduce the incidence of sanitation-related disease in slum environments.

The second involves means that provide greater opportunities for people *to move out of their existing contexts of poverty*. These include, for example, (i) growth processes that create new kinds of employment opportunity so that larger numbers of people are able to leave their marginal, stress-prone and risk-prone agricultural environments, or (ii) processes and activities that create new kinds of urban environment that enable people to move out of urban slum conditions.

The first of these bundles of poverty reduction activities includes those that the donor community is particularly interested in and supports through 'development assistance' funding. Those are obviously important and are encompassed here. But the perspective taken in this paper also encompasses the second bundle of means by which poverty reduction might be achieved – types of economic growth that provide greater opportunities for people to exit their existing contexts of poverty. Consequently, orientations of innovation that enhance such growth are included in the scope of the paper as well as those that seek to improve the lives of people in their existing contexts of poverty.

(ii) Sustainability

This perspective on the orientation of innovation is treated at greater length in another background paper for the STEPS Manifesto project.⁸ Only two brief comments are made here with particular reference to the industrial focus of this paper.

The first is about the sustainability of raising incomes above the dollar a day threshold, and then through two or three to five dollars and beyond. It seems likely that issues about innovation and industrial growth will become increasingly important in maintaining such paths of poverty reduction. This may become especially so in circumstances where climate change threatens the agricultural and natural resource foundations of movement already made along such paths.

The second is about the environmental consequences of the simple facts that: (i) industrial growth *will* occur in Low and Middle Income economies over the next two or three decades, and (ii) it is in large parts of industry that some of the greatest contributions to environmental damage will be generated. As I will stress later, that raises issues about technology and innovation that are far broader than simply those about acquiring access to 'cleaner' technologies developed through innovation in advanced economies. Issues about pervasive innovation and innovation capabilities in industrial firms in developing countries will be centrally important for reducing that environmental

⁸ See Sections 3 and 4 of Ely and Bell (2009).

burden of growth – especially as economies move into and through the Middle Income ranges over the coming decades.⁹

(iii) Diversification of Output and the Changing Structure of Production

Much of the innovative activity in industry will be oriented towards product and process upgrading within the existing lines of production in firms and industries – various ways of doing existing things better. But another orientation will be about innovation that diversifies existing lines of production by starting to do new things not previously undertaken, so changing the structural composition of economic activity in a growing economy. The importance of this issue has been re-recognised in recent years as an increasingly influential body of studies has revived key insights of an earlier generation of development scholars like Prebisch, Kuznets, Hirschmann and Chenery by giving renewed recognition to the importance of change in the composition of production and trade as a key feature of the growth and development process.¹⁰ In other words, entering into new lines of economic activity (starting new industries) is just as important as becoming increasingly efficient in existing ones – and over the longer term it is more important. Consequently, the discussion about innovation and development in the rest of this paper encompasses questions about how innovation can contribute to doing new things as well as to doing existing things better.¹¹

'INNOVATION CAPABILITIES' – AN INITIAL CLARIFICATION

I have used the term 'innovation capabilities' on several occasions above, but without explanation. At one level it is easy to clarify what I mean. The term simply refers to the capabilities needed to imagine, develop and implement innovations in the goods and services an economy produces and in how it produces them. In this paper this refers in particular to goods and services produced by industrial firms and the processes used by those firms.

However, a sad fact of life about this area of policy discussion is that these terms like 'capability' and 'innovation' usually spark off among readers widely differing images of what is under discussion, and this merely calls for further clarification. For example, the idea of 'innovation capabilities' is likely to trigger thoughts about R&D – the most commonly discussed kind of capability to innovate. Or it may prompt ideas about science-derived, novel technologies that are expected to have major impacts on growth and development. But such images are, at most, only parts of what I have in mind – and in some contexts they are quite small parts. On the other hand, some readers may associate the notion of 'innovation capability' with terms like 'technological capability'. But that is, in one sense, much more than I have in mind; and in another sense it is much less.

So let me try a slightly more elaborate explanation, with reference to Table 2 below which brings together some of the distinctions and terms used in this area. I will maintain a micro-level focus, centred on capabilities at the level of industrial firms and associated organisations. I should stress also that this framework does not specifically reflect the approach taken in the 1970 Manifesto. Indeed, one of my purposes in this paper is to highlight how the framework of thinking about innovation capabilities has changed over the years since then. Consequently, it may be best to think

⁹ The current classification of the Middle Income Countries, based on 2008 GNI per capita, includes (a) Lower Middle Income – US\$976 - \$3,855, and Upper Middle Income – \$3,856 - \$11,905.

¹⁰ In particular, Nelson and Pack (1999); Imbs and Wacziarg (2003); Hausmann and Rodrik (2003; 2006); Rodrik (2006); Hausmann et al (2007).

¹¹ Of course, the opportunities for structure-changing directions of innovation and growth are not confined to industrial expansion. They also arise from the expansion of higher-value service industries.

of this sketch as providing a kind of outer ‘envelope’ of ideas within which it is possible to incorporate the approach taken in the original Manifesto, as well as more recent perspectives.¹²

I will start with the notion of capability, and then turn to innovation.

(i) Capabilities for Innovation

In columns A and B in Table 2, I distinguish between two kinds of capability under the general heading of ‘technological capability’:

- **Production capability:** the capability to carry on producing goods and services with *given* product technology, and to use and operate *given* forms of process technology in *existing* organisational configurations;
- **Innovation capability:** the capability to *create new configurations* of product and process technology and to *implement changes and improvements* to technologies already in use.

TABLE 2. TYPES AND COMPONENTS OF ‘TECHNOLOGICAL CAPABILITY’

		Types of Technological Capability		
		A For undertaking ongoing operations with existing forms of technology already in use -i.e.	B For changing and creating new forms of production with technology not currently used -i.e.	
Components of capabilities		Production Capability	Innovation Capability	
Technology /Knowledge	- capital embodied technology	= Physical capital Tangible assets	✓	✓
	- disembodied technology	= Knowledge capital Intangible assets	✓	✓
	- Skills and people-embodied technology	= Human capital Intangible assets	✓	✓
	- Organisational aspects of production	= Organisational capital Organisational assets	✓	✓

As indicated in the rows of Table 2, both of these types of capability consist of various components. These include various kinds of asset that are labelled in different ways in different literatures. They are summarised here as various kinds of capital stock: physical capital, knowledge capital, human capital, and organisational capital – with the last of these encompassing not only the internal

¹² Though I should also stress that several of my STEPS colleagues have indicated that the ‘envelope’ I use would have to be stretched a lot further to accommodate the perspectives on innovation and capability that they prefer to use.

organisational structures and procedures of firms but also the external links and relationships they may have with other firms and related organisations.

Both production and innovation capabilities may include all of these components, though their particular qualitative characteristics will usually differ between them. For example, physical capital might be machine tools in production capability and microscopes or pilot plants in innovation capability. Similarly the linkage elements of the organisational capital of firms may consist of customer/client/supplier relationships for the sale/purchase of produced goods and services in the case of production capability; and they may consist of both bilateral organisational relationships and multi-partner networks for the sale, purchase, transfer or exchange of knowledge that can be used to change products and processes.

Finally, I should stress that the notion of 'innovation capability' in Table 2 does not map on to categories of scientific and technological activity like R&D. Hence nor do the components of innovation capability map on to components of R&D capability. On the contrary, as I will develop at greater length in the paper, the notion of innovation capability encompasses the capabilities to undertake a very much wider range of scientific, technological and other activities than just R&D. So, the idea of innovation capabilities I use may consist of highly specialised scientific and technological competences working in relatively centralised kinds of R&D organisation. But it may also include other kinds of change-generating competence that are pervasively distributed throughout production activities in the economy – often being hard to distinguish from technology-using, production capabilities.

(ii) The Notion of Innovation

In the discussion of capabilities above, I have associated the idea of innovation with terms like 'new', 'change' and 'improvement'. But how novel is 'new', and how much novelty is needed to qualify as innovation? Also, how substantial must changes and improvements be to qualify for that category?

A useful approach to answering such questions is provided by the OECD 'Oslo Manual' that was developed in the early 1990s as a framework to help standardise Innovation Surveys across countries.¹³ The Manual splits the novelty of implemented changes in production technology into four categories:

- | | |
|---|--|
| (a) Innovations ' <i>new to the world</i> ': | These occur when a firm is the first to introduce an innovation for <i>all</i> markets and industries, domestic and international. |
| (b) Innovations ' <i>new to the market</i> ': | These occur when a firm is the first to introduce the innovation in its particular market. ¹⁴ |
| (c) Innovations ' <i>new to the firm</i> ': | These occur when a firm introduces a product, process or method that is new to that firm, or significantly improved by it, even if it has already been implemented by other firms. |
| (d) Non-Innovations | These include among other things the purchase of identical models of equipment, or minor extensions and updates to existing equipment or software. |

The notion of innovation I use in this paper is similar to this framework. It encompasses not only (a) but also (b) and (c). In other words the 'degree' of novelty in innovation need not be only global. It can also be highly localised. Also, the 'scale' of an innovation can be quite a small change or

¹³ Reference here is to the third edition of the manual: OECD (2005).

¹⁴ The market may be defined (a) as firms' competitors anywhere, or (b) in terms of a geographical region.

improvement. The examples in Box 2 below provide a little concrete illustration of what lies behind these generalities.

BOX 2. THE VARIABLE NOVELTY AND SCALE OF INDUSTRIAL INNOVATION

Innovation in the steel industry

Contemporary innovation in the steel industry includes, for example, the development of globally novel smelting processes to replace the blast furnace at the iron-making stage of production – for instance, by Posco, the Korean steel company. Correspondingly, the idea of innovation capability would include the large engineering and research teams needed to develop such innovations, along with associated organisational structures (e.g. the 400-strong team of engineers that Posco has deployed for several years to develop its FINEX process, together with the organisational arrangements used to link that core innovation capability with its own research institute and also with the engineering teams of a European steel plant supplier).

But iron-making innovation also includes two other kinds of change: (i) incremental improvements in the design for new plants based on the upgrading of conventional blast furnace technology, as well as (ii) continuous streams of improvements that are engineered into the equipment and organisational arrangements of existing, operational blast furnaces. The associated innovation capabilities would include, for example, the engineering teams and shop floor personnel that Posco deploys to generate and implement such minor changes and improvements, along with the organisational arrangements linking those in-house capabilities with similar groups among its suppliers of equipment and knowledge-intensive services.

Innovation for more sustainable coal-based electricity generation

The scope of innovation in this area would include the development and introduction of globally novel kinds of clean-coal technology for electricity generation, including various kinds of technology for carbon capture and storage. Firms and governments in a small number of developing countries might seek to create such novel technologies themselves, and the necessary capabilities for this would include physical and human resources organised in a relatively small number of national, regional and global centres of research excellence contributing to the development of clean coal technology.

But innovation in this area also includes incremental improvements to existing coal-fired generating technology – both improvement that would be embedded in the engineering and design for the construction of new plants, and improvement that would be achieved by engineering and organisational changes in plants that are already in operational use. Capabilities for this kind of innovation would include (i) the knowledge, skills, experience and procedures used in organisations that undertake the design, engineering and commissioning of new power generating plants based on current technologies, as well as (ii) the engineering, technical and shop-floor teams in existing coal-based power generation companies, plus their suppliers of equipment and services, that are responsible for ‘stretching’ and ‘squeezing’ the performance of installed plants via minor technological and organisational improvements.

Finally, I should stress that my use of the terms ‘product’ and ‘process’ in talking about innovation does not refer only to physical hardware and artefacts. Products may consist of services; and process innovations may consist of changes in the organisation and procedures of production, not just to changes in machinery. Also, those organisational dimensions of production processes may include

aspects of production that are concerned with such things as logistics and marketing, not only with the kinds of activities that occur on the shop floor.

THE CORE ARGUMENT IN THE PAPER

The main thrust of the paper can be summarised in two parts. One is concerned with re-stating the Manifesto's 40-year-old challenge about strengthening innovation capabilities in developing countries – focusing on massively re-balancing their composition in order to strengthen two critically important kinds of complementarity that have been under-emphasised or even totally neglected in policy over the last 40 years. The second is about how that massive strengthening and re-balancing relates to issues about both the rate and direction of innovation and their implications for development.

(i) Massively Re-Balancing Innovation Capabilities and Strengthening Key Complementarities

The basic steps in the argument developed in this paper are quite simple, as follows.

First, the world has made a poor job of meeting the challenge laid down by the Manifesto 40 years ago. The scale of innovation capabilities created and accumulated in developing countries has been very limited, and much of what has been accumulated has had limited connection with important aspects of development. Consequently, much greater priority needs to be given to creating and accumulating such capabilities.

Second, in contrast to common arguments, such strengthening of innovation capabilities should not be seen as a (questionably efficient) substitute for acquiring technology from international sources. Instead it is needed in order to generate a much greater intensity and diversity of localised innovation that *complements* the role of technology imports.

Third, however, it is not just 'more' innovation capabilities that are needed. The composition of innovative capability also needs to be massively shifted. In particular, very much greater attention needs to be given to *kinds of capability* that are not just R&D capabilities. These include various forms of design and engineering capability, but also other kinds of change-generating knowledge and skill. At the same time much greater attention needs to be given to creating and accumulating those different kinds of innovation capability in organisational locations that differ sharply from those that have attracted policy priority in the past. Much lower *relative* priority needs to be given to building them in specialised, centralised and usually public organisations like R&D institutes and research groups in universities. Conversely, much greater priority (both relatively and absolutely) needs to be given to building them on a much more decentralised basis in firms and closely linked organisations, and hence to ensuring that they are pervasively distributed across, and deeply embedded in, production activities in the economy.

Fourth, therefore, it is time to recognise the fundamental importance of a second type of complementarity – in this case between (i) R&D-centred innovation capabilities that are deployed in specialised and centralised organisations and (ii) other kinds of innovation capability, especially design and engineering-focused capabilities that are deeply and pervasively embedded in and around production activities in the economy.

(ii) Increased and Re-Balanced Innovation Capabilities and the Direction of Innovation

Elsewhere among the papers for the STEPS Manifesto project, discussion of the *direction* of innovation is closely connected to questions about *distribution* and *diversity*.¹⁵ That close connection between the '3 Ds' is maintained here as well. Thus I will argue that the issues outlined

¹⁵ See in particular Stirling (2009) and Section 4 in Ely and Bell (2009).

above, in particular the need to strengthen the two kinds of complementarity in developing innovation capabilities, are *necessary conditions* for achieving a 3D-agenda for innovation and development – as follows.

- It is inherently difficult to shift the *directions* of innovative activity without substantial engagement in actually undertaking localised innovative activities. Or, put more positively, it is much more likely that directions of innovation can be shaped and moulded along preferred trajectories, for example towards those that offer more sustainable paths of development, if significant capabilities exist to engage creatively in at least the specification of designs and configurations of technologies.
- The introduction of new technology is likely to make only a limited contribution to shifting current patterns of *distribution* if it involves simply ‘choosing’ among the array of technological options that happen to be internationally available. Much will depend on a substantial degree of local engagement in the technology creation process. In any case, that is also often a necessary basis for being able to exercise effective choice among available alternatives.
- Almost by definition, a greater *diversity* of innovation within the contexts of developing countries calls for both (i) a much stronger base of localised innovation activity to complement technology imports, as well as (ii) a greater range and more pervasive location, of innovative capabilities to complement more R&D-focused capabilities in specialised and centralised organisations.

One might also add here the consideration of a fourth ‘D’ concerned with the *democratisation* of control over directions of innovation, involving for instance various forms of ‘citizen engagement’ with science and technology (Leach et al 2005; Leach and Scoones 2006). But some care may be needed in transferring into the area of industrial innovation such discussions about strengthening democratic control over decision-making about the directions of innovation. In some situations that involve big-ticket ‘lumps’ of new technology (dams, electrical power systems, large components of transportation systems, and so forth), such ‘citizen engagement’ with the direction of innovation via a greater role in public decisions may well be feasible. It may also be exercised in connection with public decisions about aspects of the regulation and assessment of technologies, or with respect to at least some parts of the ‘upstream’ allocations of resources to innovation activities. But a significant part of the argument here is that trajectories of innovation, perhaps especially in industry, are shaped by myriad micro-steps. Consequently, innumerable *decisions* about technology are inseparable from similarly innumerable *actions* about innovation. Consequently citizens’ engagement in large parts of the innovation process inevitably involves citizens ‘doing’ at least some of component activities of innovation.

It is important, however, to stress a further feature of the emphasis here on micro, incremental forms of innovation, and on creating widely dispersed innovation capabilities that are deeply embedded in the fabric of production. This has nothing to do with pursuing a ‘slow race’ among the possible paths of innovation and technical change.¹⁶ It is not about tortoises eventually getting there; and is not intended to achieve anything slowly. On the contrary, compared with approaches to development that have typically underemphasised the complementarities highlighted above, the purpose is to achieve acceleration – for example:

- to accelerate productivity growth in industries that have previously underinvested in complementing technology imports with localised innovation,

¹⁶ Leach and Scoones (2006) for example, argue that a ‘slow race’ (compared with other options) is a necessary basis for ensuring that technology works for the poor.

- to accelerate movement in changed directions of innovation required to achieve more environmentally sustainable forms of development.

Finally, it is also important to stress what is no doubt fairly obvious already. The approach taken here to changing both the rate and direction of innovation in developing countries involves only what one might call a *'supply side'* perspective. It concentrates on questions about the creation and accumulation of capabilities to generate innovation. While this is a *necessary* condition for both faster rates and changed directions of innovation, there are two other equally necessary conditions.

- One is about the demand for innovation. It is about the forces and 'signals', mediated via markets or other channels, by which users and consumers of technology, as well as other stakeholders with interests in the configuration of technologies, influence the innovation process by which they are created. These influences shape both the intensity of innovation activity and the types of technology that societies bring into use.
- The other is about the wider institutional and political context of innovation. It is about the broad institutional structures and political forces that have two main effects: (i) they shape the forces of demand that impinge on the innovation process, and (ii) they also shape the supply side of the innovation process – both governing the allocation of resources to building innovation capabilities, and influencing the directions of innovative activity that those capabilities pursue.

Albeit rather briefly, I will touch on questions about how these institutional and political aspects of innovation in developing countries have been addressed in past studies – first by the original Manifesto, and then also in later work.

3. INNOVATION AND INNOVATION CAPABILITIES: THE ORIGINAL MANIFESTO

To appreciate some of the key ideas about innovation capabilities in the original Manifesto, it is not enough to focus only on the document itself. One has to bear in mind that this was not a report on an academic study. It was a short consultancy report for a client within the UN bureaucracy. Most members of the Manifesto team had extensive experience of international bureaucracies and knew what was required of such public reports.¹⁷ One consequence of all this was that the document itself was not 100 per cent transparent about several of the underlying ideas that it advanced, and interpretation needs to be assisted by reference to other closely related academic work at the time.

In any case, that academic context is of considerable interest in its own right because the late 1960s and early 1970s was a particularly fertile period for academic work in this area, and both SPRU and IDS were located at an important international crossroads for many of the intellectual currents that contributed to the Manifesto. My intention, therefore, is not to provide merely a detailed textual exegesis of the document itself. Instead I will try to use the Manifesto as a window through which one can see a little more of the then current ideas about innovation capabilities within the wider framework of understanding about science, technology and innovation in developing countries.

Five strands of academic work were particularly important parts of the Manifesto's intellectual context.

¹⁷ This was perhaps especially so for Hans Singer, the Chair of the group, and Charles Cooper, the Secretary who was responsible for drafting the text. Also, a representative of the UN client (R. C. Desai) was included as a member of the drafting team.

- (i) The economic historian, Nathan Rosenberg, had been building up through the 1960s a prolific body of research on technology and industrial development. Although primarily focused on the 19th century industrialisation experience of the US and other advanced economies, this work was becoming increasingly influential in thinking about technology and innovation in contemporary developing countries, an orientation that was explicit in some of Rosenberg's own work by 1970.¹⁸
- (ii) Through the mid 1960s the OECD undertook a series of detailed studies of science and technology in several European countries that were described as 'developing' at the time - Greece, Ireland, Portugal, Spain, Turkey, and Yugoslavia. Both Charles Cooper and Geoffrey Oldham, another contributor to the Manifesto, had played a central part in these studies that included what were probably the first analyses of the bureaucratic and political frameworks of science and technology policies and institutes in developing countries. (e.g. OECD 1968a; 1968b)
- (iii) In 1970 the International Labour Organisation (ILO) was in the middle of a series of 'employment mission' studies in Colombia, Ceylon and Kenya (ILO 1970; 1971; 1972). The Institute of Development Studies (IDS), especially Dudley Seers (then Director) and Hans Singer, played a major role in these studies. Their central focus was the massive maldistribution of incomes and of access to employment. They highlighted the structural characteristics of developing country societies. In particular they emphasised their dual structure and drew attention to forms of urban and rural economic activity that, although ignored or actively disadvantaged by policy, underpinned the marginal livelihoods of large fractions of the population.¹⁹ Particularly in the Kenya study, led by Hans Singer and with participation by Charles Cooper, emphasis was placed on the significance for these groups of differences between prevailing and alternative directions of technological change.
- (iv) These ILO employment missions were deeply embedded in a more fundamental debate about the nature of development – a debate largely inspired by Dudley Seers, as summarised initially in his widely re-published paper on 'The Meaning of Development' (Seers 1969), leading to his classic 'What are We Trying to Measure?' (Seers 1972). Essentially this debate differentiated 'development' from simply the 'growth' of per capita GDP. In terms of Seers' 1972 paper, development was about creating the conditions for 'the realization of human personality'; and its evaluation should therefore take account of three linked economic criteria: 'whether there has been a reduction in (i) poverty; (ii) unemployment; (iii) inequality.' (1972: 21)
- (v) Alongside these debates about development, an international network of scholars was undertaking a collection of studies more specifically about science and technology in developing countries. Subsequently integrated by Charles Cooper in a special issue of the *Journal of Development Studies* (Cooper 1972), these included analyses of technical change in both industry (Stewart 1972) and agriculture (Bell 1972). A contribution by Amilcar Herrera about science in Latin America was particularly important as probably the first analysis of the social and political shaping of scientific research in developing countries (Herrera 1972).

Drawing on the confluence of these and other strands of work, though not always fully reflecting them, the Manifesto offered three particularly important perspectives on innovation and innovation

¹⁸ See for example his papers on 'Neglected Dimensions in the Analysis of Economic Change' (1964) or 'Economic Development and the Transfer of Technology' (1970). These were among the papers later collected together in a landmark volume in the field: Rosenberg (1976).

¹⁹ In the Kenya study, these economic activities and the groups that undertook them were described as the 'informal sector'. (ILO 1972)

capabilities in developing countries. These were about: (i) the connection between differences in the direction of innovation and changes in the distribution of employment and income; (ii) the broad scope of innovation capabilities and their interconnection in 'systems'; and (iii) the ways in which institutional and political factors shaped the structure and functioning of those systems.

THE DIRECTION OF INNOVATION AND THE DISTRIBUTION OF EMPLOYMENT AND INCOME

The Manifesto's call for a major re-balancing between advanced and developing countries in the international division of labour in science and technology was not an end in itself. The existing division was rejected as inadequate because it 'provides no basis whatsoever for development' (Singer et al 1970: para 18). Behind this was the concern that the existing division had generated a stock of technology that was not 'appropriate' for the needs and contexts of developing countries. But, although such ideas were similar to those in the debate of the 1950s and 1960s about the cross-sectional 'choice' of techniques (e.g. Eckaus 1955 or Sen 1968), the underlying ideas were about the dynamics of technical change and the consequent paths traced out over time by innovation - as reflected for example in Rosenberg's discussion of factors influencing 'the direction of technological change' (1969). More closely connected was the work of Stewart on the 'choice of techniques' in developing countries (1972). This emphasised that the choice between technical alternatives altered over time and must be viewed dynamically:

The choice available changes over time and is itself subject to choice in the sense that a country or countries can choose to develop techniques in one direction rather than another. (Stewart 1972: 99)

Although much of this work about directions of technical change had concentrated on process technologies during the 1960s, Stewart also highlighted the importance of Western-originated complexity in product technology. This influenced the options available in process technology and was itself shaped by patterns of highly unequal income distribution. Responding to the demand of high income and largely urban consumers, product suppliers were led towards advanced technological features that exceeded the functional needs of the majority of the population.²⁰

While Stewart's work was mainly about manufacturing technologies, the same issues were being explored in construction (e.g. Strassman 1968). These dynamic perspectives were also echoed in studies of agricultural technology, for example in Bell (1972), but more extensively in the work of Hayami and Ruttan (1971). At the heart of the latter was the simple argument that:

[...] a model of agricultural development in which technological change is treated as endogenous to the development process ... must start with the recognition that there are *multiple paths of technological development* (Hayami and Ruttan 1971: 43, emphasis added).

A consequent corollary was the expectation of at least some degree of diversity in patterns of innovation:

²⁰ This is essentially the same point as that made recently by Prahalad (2006) in his comments about the common approach of multinational corporations (MNCs) towards the development of products and services for 'bottom of the pyramid' (BOP) markets: 'During the last decade, many MNCs have approached BOP markets with an existing portfolio of products and services. Because these product portfolios have been priced and developed for Western markets, they are often out of reach for potential customers in BOP markets. More important, the feature-function set has often been inappropriate'. (p. 23)

[...] a common basis for success in achieving rapid growth in agricultural productivity is the capacity to generate an ecologically adapted and economically viable agricultural technology in each country or development region (Hayami and Ruttan 1971: 4).

Given this intellectual context, it was not surprising that a central emphasis in the Manifesto was about the re-orientation and re-direction of scientific and technological activities. But the intended aim of such re-orientation was less clear. For a large part it was identified simply in terms of new directions that would meet the aggregated and undifferentiated 'interests' and 'needs' of developing countries in general - contrasted with the similarly undifferentiated 'objectives' of richer industrialized countries. Even 'appropriate' or 'labour-intensive' directions of innovation were discussed in fairly opaque terms about technologies for which 'the spectrum of input requirements are closer to the pattern of resource endowments in the developing countries' (Singer et al 1970: para 96).

Perhaps a few discerning eyes might have picked up the significance of a brief remark about the existence in developing countries of a 'desperate need for reducing unemployment, and for spreading the participation and benefits of development more widely among their populations' (Singer et al 1970: para 96).

But probably not many science and technology policy-makers in the ACAST community would have associated this brief comment either with Dudley Seers' view that development should be seen essentially as a matter of reducing poverty, unemployment and inequality, or with the re-distributive aims of the ILO employment missions – as, for instance, in the section of the Kenya mission report that dealt with technology:

The question of choice of techniques in the various sectors of the economy is at the heart of a development strategy in which importance is attached to employment and income distribution. [...] Variations in techniques can be a major instrument of income redistribution towards the lower income groups of the population. (ILO 1972: 133)²¹

THE WIDE SCOPE AND SYSTEMIC CHARACTER OF INNOVATION CAPABILITIES

The Manifesto authors were adamant that, on the supply side of the innovation process, a substantial base of endogenous scientific and technological capabilities was central to achieving re-directed paths of technical change in developing countries: 'Our starting point is [...] that there is a fundamental necessity to build up indigenous scientific capability in developing countries' (Singer et al 1970: para 21). But, as noted earlier, they stressed that such indigenous scientific capability included much more than R&D. In particular, three other kinds of scientific and technological activity were highlighted:

- Various kinds of scientific and technological services (STS), such as testing, standards, surveying, and extension services;
- Scientific and technological education and training;
- Activities concerned more immediately with the application of science and technology in industrial and agricultural production, such as design, engineering, production control and medical services.

It was fairly common at that time, especially in UNESCO-linked discussions about science and technology, to note the importance of the first two. But reference to the third, especially the

²¹ This was almost certainly drafted by the Secretary of the Sussex Manifesto team (Charles Cooper) and overseen by its Chairman (Hans Singer).

inclusion of design and engineering, was much more unusual.²² Behind this lay an emerging understanding at the time about the importance of these activities in the innovation process. They were not only necessary complements to the production of new knowledge by R&D, but also contributed to innovation independently of R&D. These insights owed a great deal to Rosenberg's work – for example on the role of capital goods production and 'inducement mechanisms and focusing devices' in shaping the direction of technological change (1963; 1969). Important also was the work on innovation in the global chemicals industry by Freeman, another member of the Manifesto team. This had identified the importance of design and engineering firms in contributing to important forms of incremental innovation in the chemical industry (Freeman et al 1968). At the same time, with reference to a range of industries and infrastructure sectors specifically in developing countries, the importance of design and engineering ('engineering consultancy') was highlighted in one of the contributions to the Cooper-integrated *Journal of Development Studies* special issue (Roberts 1972).

It is intriguing that this collection of activities and capabilities was described in the Manifesto as the 'science and technology system' (e.g. Singer et al 1970: para 13), and repeated emphasis was placed on the importance of integration and coupling between these activities. In particular, in the process by which research effort is translated into economic application: 'There must be firm connections between every link in the technology application chain' (Singer et al 1970: para 70). Forty years on, this might sound a bit too close to a linear model of innovation,²³ but there were glimpses of three other aspects of a systems perspective that would not be out of place today.

(i) Internationally 'Open' Systems

While the discussion of science and technology systems centred on individual countries, these were clearly seen as 'open' national systems, an essential feature of which was interaction with scientific and technological activities in other countries. Indeed, in discussing the internal and external roles of scientific and technological activities in developing countries, the authors demonstrated a 'two faces of R&D-type' perspective (Cohen and Levinthal 1990). These activities were needed not only to develop technology appropriate to their local needs but also to provide 'their ability to absorb foreign technology'. (Singer et al 1970: para 11)

(ii) The Significance of Demand

Although an important focus of the Manifesto was on strengthening capabilities on the supply side of the innovation process, almost as much emphasis was given to the significance of demand pressures on the science and technology system. Indeed, it argued that the prevailing weakness of scientific and technological activities 'is inevitable if things are left to take their course in societies where there are no pressures of demand for scientific and technological knowledge' (Singer et al 1970: para 58).

Consequently little would be achieved by vaguely discussing general ideas about 'needs' for R&D and other S&T activities in connection with ACAST concerns about the application of science and technology for development. In principle such needs have to be transformed into 'realized demand' (Singer et al 1970: para 51), but '... the 'need' for science and technology in the developing countries is unlikely to take the form of a commercial demand coming from individual producers' (Singer et al 1970: para 117).

²² The Manifesto also included a brief recognition of the importance of the capital goods sector as a focal point in the transformation of knowledge into modes of production.

²³ However, this might be to misread the underlying perspective, as suggested by closely related work such as Cooper (1974) in which the author dismisses contemporary economists' perspectives on the relationship between scientific advance and innovation: 'Put in a bit more of the right kind of science and you get out a bit more of the right kind of innovation.' (p. 56)

This therefore required latent needs to be turned into 'perceived needs' on the part of those responsible for development policies and the allocation of resources to science and technology.

These issues about demand were particularly important because, in its prevailing form it was seen as contributing to the diversion of developing countries' limited scientific and technological capabilities into two kinds of brain drain.

The first was the well-known external brain drain by which developing country scientists and technologists moved to the advanced economies - partly because of the limited domestic demand for scientific and technological activities in their own countries and the consequent 'incapacity of scientific institutions [...] to absorb and use scientific workers' (Singer et al 1970: para 39).

The second was an 'internal' brain drain involving the orientation of a substantial part of scientific work in developing countries towards problems and issues that were 'irrelevant' to the environment in which the work was done (Singer et al 1970: para 38). While it was common at that time to see such irrelevance as reflecting the influence of agendas set in the advanced economies, together with the advanced-country training and elitist or inappropriate 'attitudes' of developing country scientists and engineers, the Manifesto attached more weight to the context in which those scientists and engineers were embedded, and in particular to the limited demand for science and technology that it generated. Consequently, as Cooper expressed it a little later, scientific activity was 'marginalized' in such economies, being largely an item of consumption rather than investment (Cooper 1972: 5).

(iii) The 'Institutional' Shaping of Systems

The discussion of these issues about demand was embedded in a deeper level of explanatory analysis. While the weakness and marginalization of innovation capabilities in developing countries could be ascribed to things like the low levels of resources allocated to S&T activities and the limited orientation of large parts of those activities to the problems and needs of those countries, these were only proximate causes.

The real causes lie deeper, in the nature of under-development itself. In brief, many of the structural and organizational characteristics of the developing countries are antithetical to the application of science and technology and, by the same token, prevent the development of what might be termed a 'realized demand' for scientific and technical knowledge. (Singer et al 1970: para 51)

This perspective would be easily recognised today by those who emphasise the 'institutional' dimension of innovation systems and highlight the ways in which this dimension, along with associated 'framework conditions', fundamentally shape the rate and direction of innovative activity. This was an important element of the intellectual context of the Manifesto and I discuss it in more detail below as the last of the three perspectives of that time that are covered in this section.

ORGANISATION, INSTITUTIONS AND POLITICS IN THE SHAPING OF INNOVATION ACTIVITIES

The Manifesto was actually quite gloomy about the realism of its proposals to expand innovative capabilities in developing countries. This pessimism was only partly about the feasibility of generating the necessary scale of resources. It was much more about the limited impact on development that was likely to be achieved even if the resources did somehow become available: '... this increased expenditure will yield economic and social benefits only if various measures of institutional reform are properly executed' (Singer et al 1970: para 5).

This theme about the necessary complement of 'reform', institutional and other, was raised repeatedly with respect to various problems in the social, economic and political context for scientific and technological activities.

At one level the problems were essentially organisational. They covered such things as: (i) the scale of the education system and the orientation of scientific and technological training; (ii) the reward structure of the scientific community; (iii) various 'organizational disorders' in public sector R&D institutes; (iv) obstacles to co-ordinating scientific and technological activities and policies that cut horizontally across vertical ministerial silos;²⁴ and (v) the organisational weakness and inadequate scale of arrangements like extension services to ensure that different kinds of scientific activity were closely couple with each other and with production in industry and agriculture. Addressing these organisational problems was critically important. Without that, there was a danger that any increased expenditure on science and technology would simply 'leak away in a kind of "scientific conspicuous consumption"' (Singer et al 1970: para 69). More forcibly, when commenting on the Manifesto's quantitative targets, its authors noted that:

...we wish to underline the fact that we presuppose that the various reforms of science and technology institutions ... discussed above will be undertaken. Unless they are, the expansion of expenditure will be impossible. Or, if there is an increase in expenditure, it will merely exacerbate existing problems and be a waste of resources. (Singer et al 1970: para 76)

At another level, the problems calling for reform were about the structural characteristics of the economy and the orientation of development policies. These included such things as the sectoral structure of the economy, patterns of agricultural landholding, the distribution of income, its associated patterns of demand for goods and services and the technologies they embodied, and the way national economies were integrated into the global economy via trade and direct investment. However, it was at around this level in its explanatory analysis that the Manifesto began to wear a bit thin, and limited light was thrown on the nature of the relationships between these features of the economy and the functioning of the science and technology system.²⁵

At a third level, behind the issues above, the constraint on effective strengthening and use of innovation capabilities was political. But here the Manifesto analysis wears even thinner. The political basis for policy is mentioned only once – in connection with the fundamental problem about reorganization in the economy:

The point is that the rationale for specific science and technology programmes is directly dependent on the seriousness and success of general development policies. Such reorganization is a slow process and political constraints may make it difficult to achieve. (Singer et al 1970: para 119)

This is perhaps where the content of the Manifesto document was most constrained by the circumstances of its production. Other closely associated studies were much more insightful about the political shaping of scientific and technological activities and their role in the economy. These included, for example, Amilcar Herrera's thesis that the incapacity of Latin American societies to use science and technology effectively for development was a consequence of the models of society pursued by 'the groups in society which until now have had political and economic power' (Herrera 1972: 19). Cooper (1974) also argued that the technical basis of production was not only related to

²⁴ As elaborated later in Cooper (1974) the emphasis on this issue drew heavily on his earlier involvement in the OECD's mid 1960s European studies mentioned above.

²⁵ Some of these issues were elaborated more extensively in the reports of the ILO employment missions, especially the report on the study in Kenya (ILO 1972). Charles Cooper explored them in more detail in subsequent publications (1972; 1973; 1974).

income distribution (as in Stewart 1972), but also, behind that, to 'questions of social organisation and the relationship between classes' (Cooper 1974: 55).²⁶

These ideas were probably developed most fully in Cooper's paper on 'The Choice of Techniques and Technological Change as Problems in Political Economy' (Cooper 1973). He illustrated key issues with reference to the context of Kenya where, as the ILO employment study had argued, the technological basis of production and consumption limited the contribution of industrial growth to employment expansion and wider income distribution. He argued that important dimensions of understanding about this relationship required moving beyond the analysis of relevant economic forces to try and 'work out the social forces that determine what they are' (1973: 295). This led for example to such issues as 'the fact that a small high-income elite has a preponderant influence on the demand for consumer goods' (1973: 295), or to details about the bureaucratic licensing system for industrial production. This had earlier in the colonial era served to protect the interests of expatriate producers of consumer goods against local small entrepreneurs and was still intact and still served essentially the same purpose 'except that it now works in the interests of a new post-colonial elite' (1973: 297).

However, at that time in the early-1970s, Cooper was also clear that: 'we are still at the very beginning' of trying to understand these forces and relationships. Indeed: 'Our grasp of how the system of political economy bears on the direction and rate of technical change is tenuous to say the least' (1973: 294)

So, one step beyond the challenge for action laid down by the Manifesto itself, there was a challenge for further academic analysis. I turn now to explore how that analysis, as well as the analysis of other issues about innovation capabilities in developing countries, was developed via subsequent research over the next four decades.

4. INNOVATION CAPABILITIES AND DEVELOPMENT: CHANGING PERSPECTIVES SINCE 1970

From the mid-1970s greatly increased research attention was given to innovation and the accumulation of innovation capabilities in the industrial sectors of developing countries.²⁷ Initially this work was concentrated in two geographically distinct strands, centred on the differing experiences of Asian and Latin American industrialisation.

The start of the Latin American strand was the work of Jorge Katz in the early 1970s (Katz 1976). This highlighted the importance of technological 'learning' – the process by which firms acquired and created knowledge, contributing to their technological and, more specifically, their innovation capability. Then a programme of detailed empirical studies covering numerous sectors and countries led to a comprehensive book on *Technology Generation in Latin American Manufacturing Industries* (Katz 1987). Other studies developed various threads of this agenda from the 1980 – for example, Tigre (1983), Cassiolato (1992), Dutrenit (2000), Figueiredo (2001), and Marin and Bell (2006).

The Asian strand initially concentrated on the experience of Korea (Westphal 1978; Kim 1980; Westphal et al 1981). This continued with studies under a World Bank research programme (Westphal et al 1985; Amsden and Kim 1985), work that was later developed more extensively in Amsden (1989) and in a stream of contributions by Linsu Kim, some of which were integrated in his major

²⁶ He also developed a more historically grounded development of this basic perspective, stressing that the contemporary developing countries typically did not offer the conditions that had earlier enabled 'organic' relationships to emerge between science and technology and between both and production in the experience of the advanced economies (Cooper 1971).

²⁷ Though most of it concentrated on only manufacturing within the industrial sectors.

study of Korea's transition from *Imitation to Innovation: The Dynamics of Korea's Technological Learning* (Kim 1997). Several other contributors worked on a widening range of other countries – for example Sanjaya Lall on India (Lall 1987); Hobday on innovation capabilities in the electronics industry in East Asia (Hobday 1995); followed by others like Ernst et al (1998), Mathews (1997; 1999), Mathews and Cho (2002), Lee and Lim (2001), Ernst (2002), and Ernst and Kim (2002).

Several studies have cut across these two strands of work to provide integrated analyses - in particular Fransman and King (1984), Dahlman et al (1987), Lall (1992), Bell and Pavitt (1993) and Rasiah (2004). Much less work on these issues has been carried out in Africa. However, there are a few illuminating case studies; e.g. Oyelaran-Oyeyinka (1988; 1994) on the steel industry in Nigeria in the 1980s, and Marcelle (2004) on the telecommunications sector in four African countries in the 1990s. Also broader overviews have been provided in Enos (1995), Lall and Pietrobelli and (2002) and Muchie et al (2003).

Despite differences between these strands of work, almost all of them moved in a broadly similar way relative to the ideas and issues addressed in the Manifesto and associated studies. This involved two trends. On the one hand, the field 'retreated' from several of the important issues addressed in the late 1960s and early 1970s. On the other, it extended and deepened understanding about several other important questions. I sketch these contrasting paths in Sections 4.1 and 4.2.

RETREATING FROM THE MANIFESTO ANALYSIS

Two important elements of the Manifesto perspective were considerably attenuated or even lost sight of altogether: (i) interest in the direction of innovation, and (ii) analysis of the political economy of innovation.

(i) The Direction of Innovation, Income Distribution and Capability Accumulation

Much of the work outlined above was embedded in three influential sets of ideas. First, especially in Latin America, considerable attention was given to Gershenkronian ideas about 'late industrialisation' being a different historical experience from earlier industrialisation in advanced economies.²⁸ Particular attention was given to the fact that late industrialisation was not based on an endogenous innovation process rooted in capabilities that were pervasively embedded in the fabric of the economy. Second, Hobday (1995) developed Gershenkron's perspective at a micro-level in his ideas about the 'latecomer firm' as a unique historical phenomenon with characteristics unlike those of firms in advanced industrial economies. Again issues about initially limited technological capabilities were a central element in that uniqueness. A major part of the challenge for such firms was therefore about proceeding through a series of stages of technological learning, so shifting from imitating to successively deeper forms of innovating. Third, these technology-centred perspectives on late industrialisation and latecomer firms became closely linked to influential ideas about 'catching-up' between economies in terms of productivity and income levels (Abramovitz 1986; Baumol 1986; Verspagen 1991).

One positive aspect of this combination of ideas was the emergence of a clearer focus on the significance of building deeper technology-creating capabilities in the industrialisation process. I return to this later in Section 4.2 and focus here on two more negative kinds of departure from the ideas that had been reflected in the Manifesto. First, there was much less interest in issues about income distribution and inequality. 'Catching up' was seen as a challenge for internally undifferentiated entities – either for whole economies and their average levels of productivity or per capita income, or for firms with their relatively homogeneous internal characteristics. Second, and

²⁸ It is not clear that the work of Gershenkron (1962) had a specific influence, but the general arguments were similar, as they were to the broad historical analysis in Cooper (1971).

closely linked to that, there was greatly diminished interest in issues about the direction of innovation. Instead interest centred on questions about catching up along trajectories of technical progress that had already been mapped out by prior innovation in the advanced economies. Questions about moving in different technological directions fell off the research agenda, being replaced by interest in the rate at which gaps could be closed between latecomer firms or economies and the technological frontier.

(ii) Political Economy, Technology and Late Industrialisation

Stewart (1978) significantly extended the ideas that had been developed around the time of the Manifesto about the institutional and political shaping of technological change in developing countries. But this more or less marked the end of the line of work on the political economy of technical change in industry that had opened up in the late 1960s. Some contributions did follow, such as Kaplinsky (1990), arguing for a less deterministic political perspective on the potential for more 'appropriate' directions in the path of innovation. However, from the late 1970s such studies were intermittent. Discussion of the institutional and political shaping of technological change in the process of industrialisation became a pale shadow of the discourse in which the Manifesto had been embedded. Nor was there any significant further development of the embryonic political analysis of the role of the scientific community and its interests in shaping science policy – the strand of work that Herrera (1972) had opened up with reference to Latin America.

There were of course numerous analyses of policy for industrial development, and many of these gave specific attention to the technological dimension of industrialisation. For the most part these amounted to endless debates about the merits of alternative trade and industry policy regimes, and they would have held few surprises for Alexander Hamilton in the late-eighteenth century or Friedrich List in the mid-nineteenth.²⁹ More useful insight was offered by policy analyses that took more explicit account of the technological dimension of industrialisation, in particular the work of Lall (1992) on technological capabilities and industrialisation, and of Lall and Teubal (1998) on 'market stimulating' technology policies. But these stopped short of examining the political and bureaucratic conditions that shaped the formulation and implementation of policy. Only a short-lived and rather thin strand of research addressed these issues, focusing on the experience of the 'developmental state' in East Asia (Amsden 1989; Wade 1990). A more substantial contribution was the examination by Evans (1995) of the role of 'embedded autonomy' in relations between the state and the private sector in industrial growth - with particular reference to policy and the contrasting development of the electronics industry in Korea, India and Brazil.

There has been little further analysis of this type over the subsequent 15 years, and the rapidly growing body of research about technological aspects of industrialisation has continued to churn out recommendations for policy without any analysis of the political and bureaucratic contexts for which they are recommended. In other words we seem to have moved very little beyond the situation that Charles Cooper lamented nearly 40 years ago when he observed that economists examining questions about technology and development had typically not taken adequate account of the systems of political economy to which their discussions referred and – more important – *through* which their recommendations would need to pass if they were to have any influence on practice. (Cooper 1973)

²⁹ Indeed, one widely cited contribution to policy debate for industrial development at the start of the twenty-first century (Chang 2002; 2003) was explicitly an argument about the contemporary relevance of the policy approaches of Hamilton and List.

EXTENDING AND DEEPENING THE MANIFESTO ANALYSIS

Over the 40 years since the Manifesto, the development of greater understanding about industrial innovation and innovation capabilities has been particularly illuminating in seven areas: (i) the importance of continuous incremental innovation, (ii) the role of business enterprises (firms) as the key actors, (iii) the key roles played by innovation capabilities, (iv) the cumulative differentiation of production and innovation capabilities in firms, (v) the component elements of technological capability, (vi) the processes by which those are accumulated and (vii) the significance of networks and interactions both in innovation itself and in the innovation capability-building process.

(i) The Importance of 'Incremental' Forms of Innovation

At the time of the Manifesto, the conventional framework for thinking about innovation was a long way from the *Oslo Manual*-type framework outlined earlier in Section 2. Instead, it had two main characteristics.

First, individual innovations were typically seen as fairly momentous entities that involved at least one, and possibly all, of the following: (i) considerable *technological novelty*, usually drawing quite heavily on relatively recent science, or even scientific 'breakthroughs', (ii) considerable *advance in performance* compared with preceding ways of doing things, and (iii) *wide applicability*, leading to considerable impact on the economy and society. Examples would include such things as the electric light bulb, nuclear power, penicillin, the computer, hybrid maize, shuttleless looms, the contraceptive pill, and the scanning electron microscope.

Second, innovation as a process was typically seen as one of three, clear cut stages: (i) *invention* – the part of a process by which the specification of an idea for a new way of doing things was developed and demonstrated (as in a patent), (ii) *innovation* – the stage that results in the first commercial application of the invention, and (iii) *diffusion or adoption* – the subsequent imitative process by which an innovation is applied by a growing number of users. The distinction between invention/innovation on the one hand and diffusion/imitation on the other was particularly important because it neatly separated the creative activities that produced innovations from the more limited activities of choosing, adopting and using them.

With these two perspectives combined, the idea that developing countries should build up their own innovation capabilities was obviously fairly absurd. It was ridiculous to think of them as producing inventions and innovations like scanning electron microscopes or shuttle-less looms. Instead, it seemed to make obvious sense to see developing countries as involved in only the third stage of imitative global diffusion, within which they selected, adopted and learned how to *use* established technologies that had earlier been innovations in the advanced economies – often a long time earlier.

However, starting from the 1960s and 1970s this framework of ideas about innovation was substantially undermined by a new set of detailed studies in the advanced, and then later, the developing economies. It became clear that it was seriously misleading to identify innovations on the basis of criteria about high levels of technological novelty, large steps in performance advance and major socio-economic impact. Focusing only on such 'radical' innovations, important as they are, would exclude a very large range of other ways in which technology (technical knowledge) was drawn on as a basis for introducing new ways of doing things. Among these studies, two were particularly important in illuminating the existence of such smaller 'units' of innovation and in demonstrating their economic significance. Enos (1962) distinguished between the Alpha phase of innovation (the initial invention and innovation of technologically novel processes) and the Beta phase (the subsequent stream of improvements), and he demonstrated that the cumulated economic gains from the Beta phase were at least as significant as the step-jump gains from the Alpha. Hollander (1965) demonstrated that innovation did not necessarily depend on substantial investment in new

plant embodying technological advances. Instead a succession of small improvements could also be engineered into existing plants during their lifetimes, and as much as 80 per cent of the total cost reduction from such change in existing plants resulted from 'minor' changes based on the firm's existing stock of knowledge, not from 'major' technical change based on new knowledge derived from research and development.

The economic historian Nathan Rosenberg (1972; 1975) drew on such studies and showed that they blew huge holes in the economists' neat and tidy distinction between innovation and diffusion. The initial commercial introduction of an innovation was just the start of a subsequent series of technologically creative activities, within which 'relatively grubby and pedestrian forms of knowledge play a disconcertingly large role' (1975: 62).

From the mid 1970s, research about technology and industrialisation in Latin America and Asia drew heavily on these ideas and highlighted two simple points. First, it was obviously the case that industrial development drew heavily on technology acquired from the advanced economies in order to start up new industries. But second, it was equally obvious that competitively dynamic, technology-importing firms, what the Manifesto would have called 'users' of technology, subsequently developed and implemented two kinds of incremental innovation: (i) successive new models of the previously imported products or new 'vintages' of previously imported process technology, and (ii) continuing streams of small improvements to existing models and installed processes. In some cases they also played key roles in supporting the development of local suppliers of engineering services and equipment incorporating such innovative improvements. In other words, in the language of Katz (1987), these firms became increasingly significant in 'technology generation', and they used this to complement to their acquisition of technology from sources in the advanced economies. Thus, it became increasingly evident by the 1980s that it made little sense to draw a line between innovation (something that happened in advanced economies) and diffusion (the kind of technological activity that happened in developing economies).³⁰

Understanding about the significance of incremental forms of innovation was further reinforced from the mid 1980s as increased attention was given to change in the organisational dimensions of production (organisational innovation). Within deep and pervasive organisational transformations such as 'flexible specialisation' or 'post-fordism', a great deal of change involved the cumulating introduction of 'incremental' steps of organisational change – as in gradual intensification of 'lean production' and the application of Japanese methods of 'Kaizen' and the 'Toyota system' (Kaplinsky 1994).

The significance of incremental forms of innovation was further emphasised by the increased attention that was given in the 1980s to the way in which innovation was typically clustered in time around particular constellations of change such as (i) 'new technology systems' - e.g. the cluster of synthetic materials innovations associated with the development of petrochemicals between the 1920s and 1950s, and (ii) new 'techno-economic paradigms' - e.g. the wave of industrial transformation associated with the development of steam power technologies in the mid-19th century or of information and communication technologies in the late-20th (Freeman et al 1982; Freeman and Perez 1988; Freeman and Louca 2001). In these kinds of historically clustered innovation, the development of radically novel individual technologies (e.g. the steam engine or the semiconductor) were critically important in opening up new, wide-ranging re-directions of innovation. But the pervasive character of these clusters of innovation also depended on a massive array of associated incremental technological improvements, developments and new applications; and these were linked with innumerable organisational innovations. And on closer inspection, even the apparently 'individual' radical innovations (whether 'the' steam engine or 'the' semiconductor)

³⁰ However, jumping ahead a little in the argument of this paper, I will show later in Section 5 that precisely this kind of sharp line between economies that innovated and those that imitated is commonly drawn in highly influential studies of contemporary growth and development.

were seen to consist of long sequences of incremental improvements and developments that progressively deepened and extended the applicability of such core, constellation-driving innovations.

Thus, by the early 1990s it became clear to the community of scholars concerned with policy analysis about innovation in both advanced and developing countries that the earlier concepts of innovation were unhelpful. They ignored a very large part of the innovation process that was treated as invisible by those who chose not to look closely at what was involved. So, it was argued, a new framework for collecting survey data about innovation was needed. Existing surveys of R&D had concentrated on measuring inputs to the narrow spectrum of innovations that involved an 'appreciable element of novelty' – as laid down in the *Frascati Manual*. Recognition of the limitations of this led to the development of the *Oslo Manual* for surveys to cover a much wider and more pervasive spectrum of innovative activity. As noted earlier in Section 2, this encompassed not only innovations that were new to the world, but also those that were new to the market or new to the individual firm. Within that changed conceptualisation, international data collection had begun to catch up with Rosenberg's much earlier (1975) emphasis on 'grubby and pedestrian forms of knowledge' that played such a 'disconcertingly large role' in innovation.

(ii) Firms: the Key Actors in Creating and Using Innovation Capabilities

Although, as noted earlier, the Manifesto elaborated in considerable detail on the nature of the scientific and technological activities that contributed to innovation (not just R&D activities, but also a wide range of others), it was pretty vague about where, in organisational terms, those activities were carried out – and hence about where innovation capabilities were to be created and accumulated. Nevertheless it is fairly evident that the key organisational actors were seen as various kinds of, usually public, organisation such as universities and research institutes. Thus, not only was the Manifesto's perspective on innovation essentially 'linear', as with references to the 'chain' running from R&D to application in production, but the distribution of technologically creative activities between organisations along the chain was highly imbalanced. It was heavily concentrated in public institutes towards one end and apparently absent from 'technology-using' enterprises at the other.

This emphasis on central and usually public organisations as the core of the innovation process was entirely consistent with prevailing views of the time, especially among international agencies like UNESCO and UNIDO. However, the research carried out from the mid 1970s on the technological dimension of industrialisation in Latin America and Asia demonstrated for those contexts what was already taken for granted in the context of the advanced economies – namely that business enterprises lay at the heart of the industrial innovation process. They were not simply 'users' of innovations produced by other actors in the system, located 'upstream' in the innovation chain. Instead, they themselves created a large proportion of the knowledge they needed, and they acquired most of the remaining proportion from other firms, not from central and public institutes. In other words, firms were simultaneously on both sides of the technology supply/demand fence. They were both knowledge-producers and knowledge-users and they interacted with other firms that were also on both sides of the fence.

(iii) The Key Roles Played by Innovation Capabilities

As it became more clearly established that innovation capabilities were deeply embedded in firms spread pervasively across industrial production sectors, a clearer picture of the roles of these capabilities emerged. This can be summarised in terms of two important complementary roles in the complex set of processes by which new technology is brought into use in industrialising economies: (i) complementing technology imports and (ii) complementing the activities of specialised and centrally organised R&D capabilities.

Local Firm-Centred Innovation: a Complement to Technology Imports

The growing body of research made it increasingly clear that the overwhelmingly predominant role of firms' innovative capabilities was to act as a complement to technology imports from the more advanced economies. Thus, the acquisition of imported technology and the localised production of technology should not be seen as substitutable alternatives, with considerations of efficiency massively favouring the former. Such a simplistic distinction is not recognisable in the pervasive experience of dynamic and, for the most part, successful firms and industries examined in these studies. Indeed the distinction is no more recognisable in this experience than it was in the earlier experience of technology-borrowing during the late-industrialisation in the United States, Germany or Japan in the nineteenth and early twentieth centuries.

It also became clear that this complementarity took two rather different, though closely linked forms. On the one hand, as noted earlier, a significant part of it arises *after* the initiation of production with imported technology. It involves the *subsequent* series of improvements and advances in products, processes and organisation, as well as modifications and adaptations to open up new markets and applications or to enable lower cost materials, equipment and other inputs to be used. And, in the same way as Hollander (1965) demonstrated for the case of rayon production in the US by the initially technology-importing Du Pont in the 1920s, several of these studies showed that these paths of continuing incremental innovation yielded substantial economic returns.

On the other hand, another part of the complementary role played by firms' innovative capabilities arose *before* the initiation of production with imported technology. Dynamic and competitive firms, especially in East Asia during the 1970s and 1980s, frequently used substantial bodies of in-house engineering, design and managerial competence as a basis for their acquisition of foreign technology. These resources were particularly important in providing the technological basis for the kinds of entrepreneurial innovation that set up firms' entry into markets and technologies that were new for the firm or economy. This role was elaborated most explicitly by Amsden and Hikino's analyses of the importance of 'project executing capabilities' that enabled Korean firms to diversify into new markets and technologies (Amsden 1997; Amsden and Hikino 1994), as well as in Kim's studies of successive steps of product and process upgrading in the Korean automobile and semiconductor industries (Kim 1997).

This kind of innovation-supported diversification of production was an important underpinning of the structural change in East Asian economies that was a central feature of their industrialisation experience over the last four decades of the 20th century (Nelson and Pack 1999). Moreover, these studies demonstrated that the 'nuts and bolts' realities of what was involved had little in common with the idea that the only thing firms in developing countries have to do is simply to choose, select and absorb technologies that are available in advanced economies. As stressed already by Rosenberg in the 1970s, the kinds of knowledge resources and the forms of search, experimentation and learning needed for such new-to-the-firm and new-to-the-industry innovation was not fundamentally different from the kinds of knowledge, search and experimentation needed for new-to-the-world innovations. Nelson and Pack (1999) later drew on a richer body of empirical evidence to make the same point: '...innovation of this type cannot be treated as simply choosing a previously unchosen element from a pre-existing choice set.' (p. 432)

Indeed, when technology importing occurs in areas that are relatively close to the international technology frontier, the kinds of knowledge base and search/learning activity required for such 'imitation' are virtually indistinguishable from those needed for new-to-the-world 'innovation'. This has been demonstrated for instance in Chuang's recent research on the electronics industry in Taiwan where diversification by firms into the large scale TFT-liquid crystal display business was based on technology licensing from Japanese firms – *preceded by* extensive, R&D and experimentation undertaken to create the basis for technology acquisition (Chuang 2009).

Local Firm-Centred Innovation: a Complement to Central R&D

The wealth of detailed studies covered here also demonstrated the importance of this second kind of complementarity. For the most part, firms drew knowledge inputs for their innovative activities from other firms, and it was usually only as firms deepened their own innovative capabilities to include design and technology development that they began to interact in significant ways with specialised R&D organisations. This seemed to arise for two reasons. First, it was only as they engaged in their own design, development or research activity that they began to generate a demand for external R&D-derived knowledge to complement their own knowledge-creation. Second, it was only as they built up significant in-house design and engineering capability that they had the capacity (and motivation) to absorb R&D-derived knowledge from external sources. Thus, it became increasingly clear that, without the complement of innovative activities and capabilities embedded in firms themselves, R&D activities in centralised and public R&D organisations were likely to be very poorly linked to innovation in industry. Consequently the articulation of a 'system' of innovation would remain extremely weak – the observable reality in very many situations in developing countries.

This view of the relationship between central R&D organisations and innovation in firms was completely different from the model that had underpinned the creation of many of these organisations in the first place. That earlier view had centred on the idea that R&D organisations could produce 'ready-to-use' innovations that only needed to be 'adopted' by firms without any involvement of their own creative activity. But by the 1990s it was becoming clear that such a model was largely nonsense. Specialised R&D organisations are very seldom able to produce such 'fast-food' versions of innovation – not because they are inherently dumb, but because 'ready-to-use-ness' requires the process of innovation to be based on a wealth of detailed understanding about production, materials, supply systems and markets. Central/public R&D organisations very rarely have such understanding. Similarly very few firms will simply adopt ready-to-use innovations of any significance. Much more often what they acquire from R&D organisations is various kinds of knowledge that they incorporate in their own innovative capability - sometimes knowledge that is embodied in the skills and experience of people they hire (learning-by-poaching).

(iv) Innovation and Production Capabilities: Gradual and Cumulative Differentiation

Detailed studies of change over time in firms demonstrated a rather obvious fact: innovation capabilities were different in several ways from production capabilities – as discussed earlier in Section 2. More interesting were insights into ways in which differentiated innovation capabilities usually emerge gradually as a result of increasing specialisation within the firm. Such specialisation can take several forms - for example, qualitatively different kinds of knowledge and skill from those underlying technology-using production capabilities. Sometimes these could be relatively easily identified - for instance, innovation capabilities would involve the kinds of knowledge embodied in formally qualified technicians, designers and engineers rather than those with different or no formal qualifications who were engaged in routine production. But in some kinds of industry they would be much less easily identified. They might exist, for instance, as deeper but unlabeled levels of understanding about the properties of materials, mechanisms and markets.³¹

The emergence of intra-firm differentiation between production and innovation capabilities also involves the development of specialised forms of organisation within the firm - for example, the creation of small process engineering sections or quality improvement groups that later evolve into technology development departments, perhaps much later becoming R&D groups. In the early stages of the emergence of such capabilities in firms, these forms of organisational specialisation might be temporary arrangements, as in the case of project teams that for short periods consist of engineers whose more usual occupations were in ongoing production operations.

³¹ Historical experience (e.g. in the late-industrialisation of the USA) included numerous examples of such barely distinguishable knowledge bases for both production and innovation.

However, studies also demonstrated that this emerging specialisation and differentiation of innovation capabilities might not occur at all. Firms could *use* successive technologies that were increasingly advanced and productive, without increasing their own capabilities to create or change what they used (e.g. Bell et al 1982; van Dijk and Bell 2007). Also, firms might differ widely in the rate at which they created and accumulated innovation capabilities alongside their production capabilities (e.g. Ariffin and Figueiredo 2004). This possible disconnection between the two kinds of capability accumulation was emphasised by Bell and Pavitt (1993; 1995) who also suggested that it had become increasingly significant in successive stages of late industrialisation since the nineteenth century. The distinction is important for three main reasons.

First, as Bell and Pavitt emphasised, it helps to lay a basis for identifying two kinds of accumulation process within late industrialising firms and economies.³² One is the process of accumulation that is well recognised in analyses of economic growth – the accumulation of technology embodied in physical capital plus the associated human capital required to *operate* the facilities at given levels of efficiency. This is the accumulation of what I describe as production capability. The other, not well recognised in conventional growth analysis, is the accumulation of innovative capabilities. As emphasised by Nelson and Pack (1999), productivity measures would reflect both kinds of accumulation. But, under available growth accounting methods, it would be likely that the productivity effects of the second would be ascribed to the first.

Second, the distinction makes it easier to envisage two notions of 'catching up'. One is concerned with narrowing the gap between latecomer firms' *production* capabilities and those of firms already at the international technological frontier; the other with increasing the level (or depth) of latecomers' *innovation* capabilities towards those of frontier-innovating firms. The first is concerned with catching up with respect to the technology that firms *use* in production, and this kind of catching up (or falling behind) can be reflected, for instance, in measures of productivity and the narrowing (or widening) of productivity gaps over time. The second is concerned with firms' capabilities to *create and change* the technology they use. In this case the gap to be closed is between copying and adopting existing technology on the one hand and improving and creating it on the other – the key transition reflected in the title of Linsu Kim's 1997 book about the firms moving from *Imitation to Innovation* in Korea. Catching up along this dimension is more difficult to measure, but it came to be roughly assessed in terms of different levels of increasingly innovative capability (Lall 1992) and the rate at which firms move through them (Ariffin and Figueiredo 2004).

That distinction opens up a more nuanced way of thinking about 'catching up' and links it to questions about the *direction of innovation* in late industrialisation. With catching-up in innovation capability distinguished from simply catching-up in production capability, and with the two not necessarily locked together, one can more easily envisage paths of industrialisation that involve catching up in innovation capabilities in order to pursue *different directions* of technological change from those already mapped out in the advanced economies. Indeed, such catching up in innovative capability is surely a necessary basis for any significant directional diversity in the development of production capacity.

Third, with the two kinds of capability accumulation separately identified, and with a clearer understanding that innovation capabilities may not simply emerge automatically as a kind of by-product from creating production capabilities, it becomes important to be clear about (i) the

³² The terminology in those Bell and Pavitt studies differs a little from that used here. 'Production capacity' (or 'production capability') is used similarly to refer to the resources used to produce industrial goods with existing, given technology. However, Bell and Pavitt (1993; 1995) used the term 'technological capability' to describe what I refer to here as 'innovation capability'. In subsequent years it has become clear that the notion of 'technological capability' is commonly used, especially in literature about the advanced economies, to refer much more broadly to both production capacity and innovation capability – hence clouding the distinction that the authors wanted to highlight.

component elements that constitute innovation capabilities and (ii) the specific ways in which they are created and accumulated – two further issues that have been illuminated by research since the 1970s.

(v) The Components of Innovation Capability and the Importance of Design and Engineering

As noted earlier, the 1970 Manifesto specified its main targets for building innovation capabilities in terms of R&D capabilities. However, it gave considerable emphasis to the importance of other, non-R&D capabilities. Over subsequent years, numerous other reports have highlighted the importance of strengthening scientific, technological and innovation capabilities in developing countries, and in most of these the focus has also been on R&D alone, but very often without any recognition of other components. Consequently, discussion of innovation policy has typically drifted toward concentrating on R&D capability alone as if that was the only component involved.³³

Such drifting of policy debate from discussions about innovation to prescription about R&D is heavily influenced by the almost exclusive focus of statistical surveys on aspects of R&D.³⁴ But this is massively distorting since many other kinds of capability underpin the process of innovation. This is so even if one concentrates on the industrial sphere and on the micro-level capabilities of firms, other organisations and their immediate networks, leaving aside for example wider issues about 'institutions' as key components of more macro-level concepts of innovation capability. Such other (non-R&D) capabilities would include things like entrepreneurial, marketing and financial competences required for innovation. Here, however, I will concentrate on another area that I summarise as 'design and engineering', and I will outline what this is and why it is a centrally important component of innovation capability.

The core technology-related activity at the heart of almost all innovation is the creation of a set of specifications (or 'designs') of the change that is to be brought into use. These specifications may take a wide range of forms. They may consist of complex designs for physical structures, chemical molecules or semiconductor layouts that are created and held in the files of computer aided design facilities. Alternatively, they may be specifications for a simple machine component drawn in the dust on a workshop floor. They may consist of different kinds of design – specifications not only for hardware in products and processes, but also for procedures and organisational arrangements. The creators of these designs and specifications typically consist of various kinds of engineer, but we must hold an open view of what an 'engineer' is in this context – not only, for instance, a university graduate in an IT system design office in Bangalore, but also an informally trained producer of machinery from recycled metal in a small workshop in the Suame Magazine area of Kumasi in Ghana.

But more than 'engineers' are likely to be involved. Even for only moderately complicated innovations, various actors may have to be co-ordinated and scheduled in order to integrate the various inputs needed to achieve innovation. Hence 'managers' will also be often involved, and again these can span a wide spectrum. One might be a computer-supported project manager responsible for integrating the different specifications and other inputs required to create and bring on stream a new petrochemical plant or a new port facility. Another might be an NGO project manager trying to integrate suppliers of design services, quality management and export finance with product-upgrading activities in the value chain linking Ghanaian basket producers, exporters and international buyers.

³³ A welcome exception was in part of the study undertaken by the Millennium Project Task Force on Science, Technology and Innovation (UN Millennium Project 2005c). This gave considerable prominence to the role of 'engineers' within S&T capabilities. However, as I show later in Section 5, none of that emphasis carried through to the overall summary report (UN Millennium Project 2005a), where the only concrete actions about strengthening STI capabilities were about increasing expenditure on R&D.

³⁴ I address this issue about the relationship between available data and the focus of policy at greater length in another STEPS Background Paper: Bell (2009).

Across this spectrum of design/engineering and associated management activities, the specifications for new facilities, products, systems and so forth will occasionally be pure imitation. But very often they will involve some degree of novelty. As discussed earlier, this may vary widely, including minor incrementally novel innovations occurring widely across industry. Consequently it is the pervasive existence of capabilities to undertake these design, engineering and management activities, along with the innovativeness of the changes they introduce, that will be central to two key development purposes stressed in this paper: raising the rate of innovation and shifting its direction.

Given the usual focus of policy discussion on R&D as the key activities driving both the rate and direction of innovation, that assertion raises questions about the relationship between design and engineering (D&E) on the one hand and R&D on the other, and in particular about the knowledge-base that D&E activities draw on in playing their creative innovation role.

It is entirely misleading to think of design and engineering simply as a 'downstream' extension of R&D – undertaking the next steps along the line in a process that runs from its supposed 'core' in the creation of new knowledge in R&D to its application in production. Instead, it makes much more sense to think of D&E as a set of activities that are undertaken in their own right in the vast majority of cases, being directly linked to R&D in only a small minority.

Overwhelmingly these activities draw on existing stocks of knowledge that they already have available, and they create novelty out of combining elements of those knowledge bases in new ways. For example, engineers designing road bridges for infrastructure projects draw almost entirely on existing design principles, methods, tools, data, and experience of particular design approaches in previous bridge-designing/building projects. They apply these to create novel configurations to meet the varying requirements of different bridging situations; but they also have the opportunity to create novelty leading to reductions in cost or improvements in performance between successive bridge-building projects. In the same way, engineers designing paper mills or petrochemical plants usually create novelty by drawing very heavily on such combinations of existing principles, tools, methods and data, plus experience of previous design projects and their outcomes.³⁵

As a supplement to their existing stocks of knowledge and experience, designers/engineers draw periodically on recently created knowledge. They sometimes contribute directly to that as a result of their own experimentation and experience accumulation, but when they do the additions they make to the knowledge base are usually not dramatically novel. However, designers/engineers typically play quite modest roles in creating new knowledge, as they draw most of it from other more specialised actors undertaking various forms of technological development (D) or perhaps research (R). In some cases, such externally sourced new knowledge will again not be radically different from what was previously available and it enables relatively modest incremental improvements in performance to be achieved via D&E. But in other circumstances, new knowledge may be more radically different from the existing stock – perhaps, but not always, permitting more substantial improvements in performance or the introduction of totally new kinds of production activity.

However, even when D&E activities are linked in this way to R&D, it does not mean that they are just a one-way conduit for incorporating new knowledge from R&D into designs and specifications for innovation. On the contrary they play an equally important role running in the other direction – *from* the production of goods and services *to* the execution of R&D. This link with R&D that runs in the opposite direction from what is usually described can be identified at two levels.

³⁵ Across these different kinds of D&E, the balance between formally structured elements of knowledge (principles, tools, data, etc.) and less formally organised experience varies widely. For example, the designers of semi-conductor layouts will draw especially heavily on the former, while informally trained machinery producers in Kumasi will draw particularly heavily on the latter.

First, in quite general terms, D&E performers actively 'pull' on R&D when their existing knowledge base is inadequate to meet effectively the challenges and opportunities they confront. Entrepreneurs, managers or engineers may pose demands for specifications of products or production systems for which the existing knowledge stock is inadequate for effective designs.

But second, it is also important to identify more detailed aspects of this relationship. The 'pull' on technological development activities is not simply a generalised 'demand' for innovation. It is a much more specific demand for particular kinds of knowledge input for innovation. This may arise as engineers/designers identify from their accumulated learning about past experience particular focal points where the search for new knowledge might be especially productive. In this and other ways generalised demand for some form of 'improvement', when mediated through the design/engineering interface, becomes concretised in the form of specific technical configurations or performance requirements that shape the search process undertaken by those engaged in R or D.

Thus the 'pull' processes from D&E are important in achieving articulation in the systemic structure of innovation activities and capabilities, and that is at least as important in overall system articulation as its downstream role in the 'push' from new technology development by R&D. This important *two-way* R&D-related role performed by D&E capabilities, together with their role in innovation that is independent of close links to R&D, raises questions about the aggregate scale of these capabilities. In particular what is the magnitude of the resources involved relative to those in R&D capabilities that are the centre of attention in so much debate about innovation and STI policy?

Unfortunately only fragments of information are available. Some of these, drawn from the experience of the USA, one of the most R&D-intensive economies in the world, are particularly interesting. They are derived from a 2003 survey of the primary job activity of people with a science or engineering (S&E) first degree and/or an S&E type of occupation.³⁶ Only about 10 per cent of the responding scientists and engineers reported undertaking R&D as their main job activity. This covered both basic and applied research, as well as technological development. A larger proportion (13 per cent) carried out various kinds of 'Design' - concerned with equipment, processes, structures, models, etc., as well as the design of computer applications and systems. Even more of them (19 per cent) undertook various management and supervision activities, frequently concerned with managing projects, quality and productivity – and hence likely to be often concerned with managing change and improvement in production.

In other words, in one of the most R&D-intensive economies in the world, the number of respondents to the survey who reported their primary activity as some form of design and engineering was substantially greater than the number reporting it as R&D. If one adds to that the other respondents who were primarily engaged in managing innovation as part of their management and supervision activities, the number undertaking what I describe as 'design, engineering and associated innovation management' was possibly two or three times larger than the number undertaking R&D.

In principle one would expect that ratio to be greater in less R&D-intensive economies than the US. Unfortunately, however, relevant data about that are not available in even a moderately systematic form.

(vi) Processes for Creating and Accumulating Innovation Capabilities

An important strand of evidence from the post 1970 studies was about the sources of industrial innovation capabilities. In particular, they demonstrated that they were in very large part *created* by firms themselves, not just acquired and accumulated by them. This was especially so with respect to

³⁶ I elaborate on this information in another STEPS Background paper: Bell (2009). The detailed data and source are provided there.

the human capital component of capability – people with the kinds of knowledge and skill needed to imagine, specify and implement changes in firms’ products, processes and organisational arrangements for production.

As is well recognised, part of this particular kind of human capital is created in various kinds of education and training organisation, and then hired by enterprises. But the growing body of post 1970 studies made it increasingly clear that firms themselves have to add substantially to what is initially hired, and this involves their own training and organised learning. Beyond that, another major component was shown to be internally generated new knowledge. In order to change their production activities, firms had to acquire and accumulate bodies of originally created understanding about the firm-specific details of their technologies and markets.

An important feature of the processes by which these capability components are created is that they require specific kinds of purposeful activity and effort on the part of firms. They do not simply emerge quasi-automatically as time passes or as production experience is accumulated. Instead, their creation requires particular kinds of training that are different from the training needed for ongoing operations. They need specific kinds of learning experience that are different from the experience of routine production; and they depend on specific activities to acquire knowledge about the technological properties of products and processes that are not undertaken as matters of routine production - for example, various kinds of ‘reverse engineering’.

Over time, with increases in the level of novelty of the innovation generated by these capabilities in firms, the kinds of specialised training, learning, organisation and process of knowledge acquisition might come to be recognisable in terms of PhD scientists, laboratories, off-line experiments and R&D activities - the tip of the iceberg of much deeper and broader innovation capabilities.³⁷ But these ‘advanced’ kinds of innovative capability often take decades to emerge; and they do so only in relatively large and technologically sophisticated firms.

Thus, in contrast to simplistic notions of ‘learning by doing’, with their implications of relatively passive and costless processes of acquiring competences, these activities of training, organised learning and localised knowledge generation require intensive effort, strategic management and considerable expenditure on the part of firms. In their more elaborately organised forms, they involve a sequence of activities that integrates learning and training efforts that are largely internal to the firm with the acquisition of skills and knowledge from outside.

This interaction between internal learning and external knowledge acquisition merits some elaboration, using the example of the automobile producer, Hyundai, in Korea – drawing directly on Kim’s (1998) study. He showed how the firm organised major steps of learning in a sequence of four activities (Figure 1): (i) internal preparation for the acquisition of external knowledge, (ii) the acquisition of that knowledge, (iii) its effective assimilation, and (iv) its subsequent improvement – so creating a higher knowledge base for the preparatory phase of another cycle of learning.

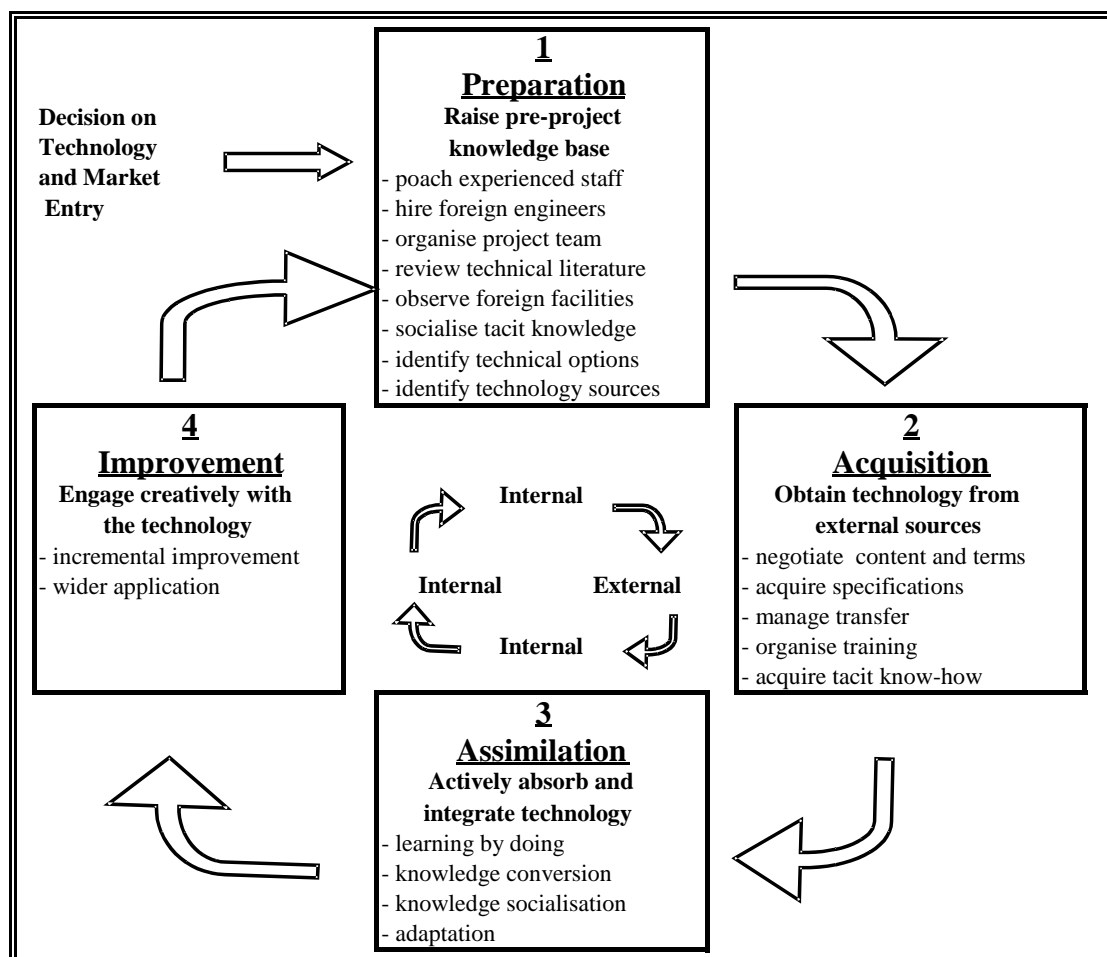
As well as contributing to the firm’s ‘catching up’ in production capability, the successive repetition of this four-step cycle played the key role in taking Hyundai through a succession of qualitative discontinuities in the cumulative development of its design, engineering and innovative capability. Access to external knowledge and skill was a key issue at each of these discontinuities. But three of the four steps in each cycle were primarily concerned with internal learning efforts that played three roles in complementing external knowledge acquisition in the overall learning process: not merely (a) ensuring *ex post* the effective absorption of whatever had been acquired externally in the first place, but also (b) creating the base of competence for

³⁷ For one example of this iceberg metaphor see Figure 1.3 in Watkins and Ehst (2008: 31) - drawn from a wider discussion of the idea in Arnold et al (2000).

subsequent incremental endogenous innovation, and (c) creating *ex ante* the necessary knowledge base for acquiring further elements of external technology.

As emphasised above, an important feature of such learning processes is that they require expenditure outlays by firms. They constitute investment projects, but with knowledge-capital rather than physical capital as the kind of asset being accumulated. But for individual firms such investment is much more risky than investment in physical capital. The knowledge assets are much more 'mobile' and can be lost to other firms by the investing firm - to the benefit of the wider industry and economy. This has important implications for policy because this kind of investment in knowledge assets has similar kinds of characteristics to other forms of such investment: (i) it is risky for firms with uncertain returns, and (ii) it also involves imperfect private appropriation of those returns, with public spillover benefits likely to arise.

FIGURE 1. INTEGRATING INTERNAL AND EXTERNAL LEARNING: HYUNDAI 1960S – 1990S



Source: Based on Kim (1998)

In the case of other kinds of investment in knowledge assets it has been widely recognised that these characteristics call for public policy interventions. For example, governments in developing countries frequently intervene in at least the following three ways:

- they use public resources to fund the creation of knowledge via R&D in various kinds of public organisation;

- they use public resources to support the creation of knowledge-intensive human capital in the tertiary education sector;
- they sometimes use public resources to subsidise the creation of new knowledge by firms via their own R&D (by fiscal incentives or various types of grant mechanism).

However, hardly any attention is given to measures for fostering the creation of *non-R&D* innovation capabilities *in and by* industrial firms.

(vii) The Significance of Systemic Interactions in Innovation

By the 1980s the framework used to analyse industrial innovation in the advanced economies shifted away from an emphasis on individual firms to focus on innovation systems in which those firms were embedded. This shift had two main elements.

First, innovations came to be seen as the creations of not just individual innovative actors but the outcome of interactions between sets of actors. Particular emphasis was placed on interactions between firms – as in Lundvall’s (1988; 1992) elaboration of ideas about ‘user-producer’ interaction, but also between firms and other organisations like universities and research institutes. Consequently innovation capabilities came to be seen as embedded not just in the internal capabilities of individual organisations but also in the interactions between them, and these links were identified as specific components of the capabilities of innovation systems – at the level of firms, industries, regions and national economies.

Second, these constellations of interacting organisations were identified as being embedded in ‘institutions’ – defined in numerous different ways, but essentially consisting of ‘rules of the game’, prevailing norms and principles about ‘the right’ way of doing things, policy regimes, and the bureaucratic and political structures that underpinned those regimes. Interactions between the core body of actors contributing directly to innovation and these contextual institutions was seen as important in shaping the nature and ‘effectiveness’ of innovation, as emphasised in one of the first of the innovation system studies, Christopher Freeman’s examination of the ‘innovation system’ in late-industrialising Japan (Freeman 1987;1988).

The first of these components of the innovation system framework has received enormous attention in the advanced economies and has been elaborated in numerous ways, with the importance of ‘system’ interactions being reinforced by related perspectives such as idea of ‘open innovation’ (Chesborough 2003). The second component has attracted much less attention.³⁸ Consequently, as in most diagrams of innovation systems, the notion of ‘institutions’ has remained for the most part just a large ‘box’ of vaguely defined, heterogeneous elements. Only recently have steps been taken to try and develop greater and more differentiated conceptual clarity about the contents of the box (e.g. Nelson and Sampat 2001; Nelson 2008); and empirical analysis remains rare, except in the area of IPR regimes.³⁹

The basic notion of innovation systems was rapidly transferred for application in developing countries. This involved two steps. The first was the simplification of academic analysis for use in policy prescription in OECD countries. Then the second involved the transfer of such prescriptive simplification to developing countries.⁴⁰ In the process, several things happened.

³⁸ An exception to this has been the extensive examination of intellectual property rights (IPR) regimes and their influence on innovation

³⁹ Apart from analyses of IPR systems, other exceptions were: (i) in developing countries, the small number of studies of ‘developmental states’ and Evans’ analysis of ‘embedded autonomy’ – as noted earlier, and (ii) in advanced economies, the studies collected in Casper and van Waarden (2005), in particular those of the influence on innovation of broadly different varieties of capitalism.

⁴⁰ I discuss this in more detail in another STEPS Background Paper: Bell (2009).

First, the idea lost its early association with 'open' systems – i.e. systems that interact with others, in particular via flows of knowledge but also in terms of their institutional contexts. So, for instance, the idea of 'national' systems of innovation came to be identified as systems that almost exclusively involve activities occurring *within* national boundaries.

Second, the idea lost its origins as a device for helping to analyse the nature and implications of *difference* (e.g. difference between degrees or types of linkage articulation among actors, differing levels or types of innovation capability possessed by individual actors, difference between organisational arrangements and structures, and difference between key features of the institutional contexts for innovation). Instead, perhaps to a greater degree than among the advanced economies, particular system features came to be seen as parts of an ideal model. Consequently, an innovation system was perceived as necessarily having a minimum set of characteristics X, Y and Z; and, if those were not present in a particular developing country situation, then it was described as 'not having' an innovation system - the apparent implication being the strange idea that there exist some countries (or regional or sectoral parts of them) that have no actors linked together in any kind of way to undertake at least some forms of innovative activity within some sort of institutional framework.

Third, the innovation system idea, or at least the terminology associated with it, was often found attractive by the parts of government that had responsibility for the specialised area of 'science and technology policy'.⁴¹ Consequently the idea of the national innovation system came to be identified largely in terms of the sub-set of activities that these parts of government were directly responsible for funding. Hence, because 'S&T policy' was so often identified primarily as 'R&D policy', the national innovation system idea came to be seen primarily as the set of public organisations that undertook R&D – research institutes and university-based R&D groups.

Thus models of 'the' national innovation system in many countries focused primarily on the public R&D-performing organisations *within* those countries - mainly universities and research institutes. At the same time a huge amount of policy attention was given to issues about strengthening linkages *between* those central organisations on the one hand and enterprises in industry on the other. In contrast, little attention has been given to the aspects of innovation systems and innovation capabilities that have been discussed in this paper.

5. INNOVATION, GROWTH AND DEVELOPMENT: ALTERNATIVE PERSPECTIVES

In the previous section I reviewed studies since the 1970s that have focused specifically on innovation and the creation of innovation capabilities in developing countries – a particular segment of the overall development process. For the most part these have been academic studies with policy prescription as a secondary concern. In this section I turn to a number of contemporary studies that have been much closer to the political and bureaucratic realms of policy prescription for international as well as national action about development. These fall into two categories.

The first includes what I describe as 'mainstream' analyses and prescriptions about development and growth. These are major 'flagship' reports dealing fairly comprehensively with multiple dimensions of the overall process of growth and development, and they include at least some examination of questions about science, technology and innovation. I focus on four of these reports. They are reviewed in Boxes A1 - A4 in Annex 1.

- The Commission on Growth and Development (2008) *The Growth Report*;

⁴¹ In other words, bodies like Ministries of Science and Technology or National Councils for Science and Technology, rather than line ministries that often had responsibilities for more firm-centred technological and innovation activities in their sectoral domains – e.g. Ministries of Industry or of Transport.

- Commission for Africa (2005) *Our Common Interest*;
- UN Millennium Project (2005) *Investing in Development* – both the Main Report (2005a) and the Overview (2005b);
- World Economic Forum (2002) *The Global Competitiveness Report 2001-2002*.⁴²

The second category does not deal with across-the-board development issues but focuses specifically on policy for science, technology and innovation. I focus on one such report that addresses these issues with reference to the whole of Africa:

- NEPAD (2006) *Africa's Science and Technology Consolidated Plan of Action*.

At a broad level the purpose of reviewing these studies is quite simple: to identify the kind of perspectives on innovation and innovation capabilities that are reflected in such contemporary 'close-to-policy' reports. But there is also a more specific purpose: to explore the extent to which such policy perspectives appear to have been influenced by the body of understanding about innovation and innovation capabilities reviewed in the previous section. In effect, this section of the paper reviews an aspect of the 'effectiveness' of the post-1970 research reviewed earlier in Section 4. It asks whether one can trace in these reports a significant impact of that research on two important communities of scholars, politicians and bureaucrats who have addressed two areas of policy in recent years: (i) broad approaches to achieve growth and development, and (ii) strategies for science, technology and innovation in a large block of developing countries.

Fairly simply, the answer is 'No'. The reports reviewed here give little attention to innovation and, to the extent that they engage with issues about building innovation capabilities, there is no sign of the main trends of change in understanding that I have outlined in Section 4. At least from the evidence of these reports, the research contributing to that understanding seems to have failed to make any impression on these two policy communities.

I elaborate on this below in two steps. First, I comment in Section 5.1 on the four reports about general aspects of growth and development. Then I comment in Section 5.2 on the *Consolidated Plan of Action* for science and technology in Africa.

CONTRASTING PERSPECTIVES ON INNOVATION IN GROWTH AND DEVELOPMENT

Part of the basis for the conclusion immediately above is provided in Table 3 below where some of the key insights and understanding reviewed earlier in Section 4 are summarised in the left-hand column. On the right-hand side I summarise the views about equivalent issues that are expressed in the four broad development reports. The contrast between the two columns is striking.

The difference is evident at a very basic level about whether innovation and innovation capabilities are needed at all in developing countries. As highlighted on the right-hand side of blocks 1 and 2 in Table 3, a pervasive view in the four broad development reports is that developing countries are simply 'non-innovating' economies. They can meet, and they should meet, almost all their needs for technology by choosing and adopting it from sources in the advanced economies. This is in total contrast to the view reflected in all the material reviewed in Section 4 above – namely that localised innovation, as a complement to technology imports, is a centrally important feature of the development process.

⁴² This report was not specifically about developing countries, but it included an influential examination of issues about technology and innovation in developing countries. This elaborated on, and provided quantitative analysis of, perspectives about innovation and development that underpin much of the thinking in the previous three reports.

This contrast is rooted in a fundamental difference of view about the concept of innovation. On the one hand, innovation-centred research over the last 40 years, and starting earlier in the work of scholars like Enos and Hollander, has built up a view of innovations (the 'outputs' of the innovation process) as encompassing a very wide range of phenomena running from radical global novelties to incremental and 'new-to-the-firm' improvements. On the other hand, the idea of innovation underlying the broad development reports is exclusively about global novelties.

Moreover, one of the four reports (World Economic Forum 2002) provides a systematic quantitative reflection of that view. On the basis of a very narrow set of statistical indicators of innovative activity, the economies of the world are divided into two categories: a 'core' group of countries that innovate and a 'non-core' group that do not.⁴³ To simplify only a little, the distinction is made entirely in terms of the number of patents taken out in the USA. This is done in two steps. First, a threshold of 15 per year during the 1980s neatly identifies part of the core group: 18 OECD countries. Then, second, an assessment of whether economies crossed that threshold between 1990 and 2000 was used to add another small group to that initial core: Taiwan, Iceland, Ireland, Hong Kong, Singapore and Korea. These two groups of core economies were innovators. All the rest were described as not having shifted from technology-importing to technology generating and so had failed to make the 'transition from technological adoption to innovation' (World Economic Forum 2002: 38).

There is, however, a degree of ambivalence about innovation in developing countries in these four broad development reports. Although local innovation is treated as irrelevant and inefficient in these countries, the reports also include comments about strengthening their capabilities for innovation. However, these are largely shaped by the underlying view of innovations as global novelties and of the innovation process as something that consists very largely of R&D. Consequently, as summarised on the right-hand side of blocks 3, 4 and 5 in Table 3, the views about selected aspects of innovation capability in developing countries – its knowledge base, organisational basis and source of human capital – are in stark contrast to those I have reviewed earlier in Section 4.

TABLE 3. CONTRASTING PERSPECTIVES ON INNOVATION IN DEVELOPING COUNTRIES

Insights from research between the mid 1970s and mid 2000s (From Section 4 above)	Perspectives in selected 'mainstream' development reports: mid-to-late 2000s (From report summaries in Boxes A1 - A4, Annex 1)
1. Innovations and innovation processes	
<ul style="list-style-type: none"> - Although global novelties are important, innovation also consists largely of 'small' improvements and 'minor' developments - The distinction between innovation and diffusion is therefore blurred and misleading - So simple distinctions between innovating and non-innovating economies are also misleading because: - Efficient diffusion involves creative development and shaping of technologies across all economies 	<ul style="list-style-type: none"> - Innovations consist almost entirely of global novelties, usually patented, and once brought into use these remain largely fixed and unchanging - The distinction between innovation and diffusion is clear-cut - The global economy can be easily divided into innovating and non-innovating economies - The latter include the Low-Income countries and most of the Middle-Income ones as well

⁴³ I discuss more widely the way in which policy perspectives are shaped by statistical indicators in another STEPS Background Paper: Bell (2009).

2. Importing vs. creating technology

- Technology importing and localised innovation are complementary activities
- The former is often much more creative and complex than simply choosing and adopting technology
- Once in use in dynamic economies, imported technology is stretched and improved by continual improvement, development and diversification
- Technology imports and localised innovation are alternatives
- The latter is usually costly and inefficient in developing countries so technology imports are preferable until High-Income status is reached
- Technology importing involves merely choosing, adopting, and occasionally adapting technologies to suit local circumstances

3. The knowledge base for innovation

- A very large part of the knowledge base for innovation consists of existing stocks of knowledge used in 'design and engineering' (D&E) activities
- Innovation depends on detailed knowledge in the context of production and on new knowledge generated in D&E activities
- D&E-driven innovation also draws on some new knowledge from the ancillary activities of R&D
- Innovation is based heavily on new knowledge derived from science, research and experimental development – i.e. from formally organised R&D
- R&D provides most of the knowledge needed to produce innovations that are more or less 'ready-made' for adoption by 'users'
- R&D, the core of the innovation process, may use D&E for ancillary 'downstream' links to production

4. The organisational basis for innovation

- Most of an economy's innovation capabilities are dispersed across the economy and deeply embedded in the organisations that undertake production
- As a result the 'users' of (e.g. industrial) technology also produce much of it
- So, organisations on the 'demand side' of the process are also an important on the 'supply side'
- To the limited extent that developing countries need them, R&D capabilities for innovation operate in distinct and usually centrally located organisations
- These exist at the 'front-end' of a chain of separate but linked organisations
- This 'supply-side' delivers innovations to their users that are other organisations on the 'demand side'

5. Creating and accumulating the human capital for innovation

- One important stage in creating large elements of human capital for innovation (but not all of it) occurs in various types of education and training organisation – sometimes in advanced economies
- Strengthening this part of the innovation system requires policy intervention and public subsidy
- Additional stages need to be added by cost-incurring training and learning in production organisations
- Strengthening this part of the innovation system also requires policy intervention and public subsidy
- To the limited extent that developing countries require it, human capital for innovation is created by education and training (primarily tertiary and postgraduate) – often in advanced economies
- Strengthening this part of the innovation system requires policy intervention and public subsidy

My emphasis on these differences needs to be reinforced by another contrast that is not explicitly flagged in Table 3. This is about the inclusive and exclusive nature of the views in the two columns. For the most part, those summarised in the left-hand column do not exclude recognition of the kinds of innovative activity, capability and organisational arrangement covered on the right-hand side. For example, perspectives in the left-hand column fully recognise the importance of such things as globally novel technologies, technology imports, specialised and centralised R&D, and the key role of tertiary education. In contrast, the perspectives summarised in the right-hand column are much more excluding with respect to the left-hand side. Seen from the right, most of the activities, resources and organisational arrangements emphasised on the left lie on the 'wrong side' of supposedly clear conceptual distinctions and operationally meaningful boundaries. Distinguished in that way, they are simply unimportant and irrelevant in developing countries. In the extreme, they do not even exist.

Broadly therefore, the view from the left of Table 5 is that what is included on the right is 'not enough', and that it needs to be complemented by insights from the post-1970 research that is summarised on the left. But the view from the right sees very little of any significance on the left. At the same time, the view from the left finds few clear-cut conceptual distinctions in the fuzzy world of innovation, and it is reasonably comfortable with ambiguity and blurred operational boundaries. But the view from the right finds this an uncomfortable and unsatisfactory way of looking at the world – not least because much of it cannot be fitted into the categories and concepts already embedded in familiar types of standardised data.

If the 'mainstream' perspectives outlined on the right-hand side of Table 3 have practical influence on policies for growth and development, two kinds of probable consequence seem important.

One is about the *rate* of innovation and the corresponding rate of growth and development. Both micro-level studies and macro-level analyses (e.g. Nelson and Pack 1999) suggest that rates of growth of productivity and rates of structural diversification of the economy are likely to be enhanced by the kinds of localised innovation in developing countries that I discussed above in Section 4.

The second is about the *direction* of innovation. Without significant local innovation occurring in developing countries, the possibility for influencing the direction of innovation is severely constrained. Indeed it is interesting to note that this seems to be what is expected within this 'mainstream' perspective. For example, the report of the Commission on Growth and Development (Box A1 in Annex 1) specifically had nothing to say about innovation in connection with its discussion of rising inequality. At the same time it seemed to presume that innovation in only the advanced economies had any relevance to the issue of climate change mitigation.

In this respect, these views are essentially pre-1970 Manifesto. By giving no attention to questions about local innovation and the direction of technological change in developing countries, they leave such questions to be discussed only in 1960s terms – as a matter of either (i) choosing from the technologies that happen to be available on the shelves of the technological 'supermarket' of the advanced economies, or (ii) persuading the funders of R&D in advanced economies to allocate greater expenditure to generating a wider array of technologies *for* developing countries.

AFRICA'S 2005 CONSOLIDATED PLAN OF ACTION FOR S&T: A VISION FROM THE 1960S

As noted earlier this development report concentrates on policy for science, technology and innovation (STI). It is 'mainstream' in the sense that it was created by a process that directly involved senior African bureaucrats, experts and politicians involved at the highest levels of policy-making for STI both nationally and internationally. This process consolidated a number of science and technology programmes of the African Union (AU) Commission and The New Partnership for Africa's Development (NEPAD) that emerged from a series of regional workshops held across Africa. The process of integration was specifically prompted by the AU in 2003, and its result – the *Consolidated Plan of Action* (CPA) – was adopted by the African Ministerial Council of Science and Technology (AMCOST) in 2005 and endorsed by the AU Summit in 2006. The overall *Consolidated Plan* carried an estimated budget of US\$ 200 million.

Although its title refers only to science and technology, the CPA is in principle deeply embedded in concerns about innovation and its role in achieving 'Africa's common objective of socio-economic transformation and full integration into the world economy' (2006: 6). Consequently it rests on three core concerns – not only about 'capacity building' and 'knowledge production' innovation system concept. On the one hand it is partly underpinned by concerns about problems and limitations that are plaguing 'the continent's science, technology and innovation system' (2006: 7); and on the other

it places emphasis on developing 'an African system of research and technological innovation' (2006: 6).

I comment separately on two parts of the report. I refer to one of these as the 'core' – a number of sections that cover actions to be taken in a number of fields of science and technology. The second part includes several sections covering policy, implementation, funding and governance. I comment only on the policy component.

(i) The Core of the Consolidated Programme

What I refer to as the 'core' of the CPA was organised around five Programme Clusters concerned with: (1) biodiversity, biotechnology and indigenous knowledge; (2) energy, water and desertification; (3) material sciences, manufacturing, laser and post-harvest technologies; (4) information and communication technologies and space science and technologies; and (5) mathematical sciences. Each of these included distinct Programmes, and within each of these there were a number of indicative projects and activities – amounting to an impressive array of about 30 specific kinds of action.

Three types of activity were pervasively important across the five Programme Clusters.

First, many of the projects were organisational initiatives to reduce the fragmented, isolated and often small-scale character of activities scattered across the continent. These included various kinds of database and inventory to make more widely known what was being done and to provide more open access to the data and results from those activities. They also included steps to facilitate interaction and co-operation between the institutes, units and individuals undertaking these scattered activities - various kinds of network and virtual organisation. There were also projects to consolidate in regionally integrated centres various kinds of STI activity that were thought best undertaken at a more effective, larger scale, and hence on a collaborative and multi-country basis.

Second, many projects were designed to strengthen the human resource base for STI activities.

Third, many were concerned with strengthening and implementing various kinds of knowledge production and technology development.

A striking feature of these actions is that they addressed only a limited part of Africa's science, technology and innovation system. Almost all of them were concerned with science and technology organisations located at the 'up-stream' end of an implicit linear chain of activities undertaken largely by public and centralised organisations like research institutes and universities, and designed to deliver innovations to users at the end of the line. In contrast almost none of the actions had anything to do with the large part of the innovation system that is located in production organisations spread across the agricultural, industrial, and service sectors of the economy (both private and governmental). This was evident in several ways.

The various organisational arrangements for creating and strengthening links among actors in the African innovation system were concerned almost entirely with links *among R&D institutes and universities*. There is no mention of any action concerned with strengthening or creating innovation-related links *among production enterprises*. At the same time the infrequent reference to links between these 'upstream' organisations on the one hand and enterprises on the other are clearly concerned with the latter as simply the users of innovation outputs created by the former. There is, for example, no comment on them playing any kind of role as co-creators. Similarly, the proposed regional centres for integrating STI activities at more effective scale are specifically centres of *research and academic* excellence, and they are seen as being located in the same 'upstream' part of the innovation system. In contrast, there is no mention of fostering centres of *innovation* excellence that would be located in and organised by industrial or other enterprises.

In a similar way the important actions to create and strengthen human capital for STI activities are concerned entirely with activities in specialised education and training organisations, mainly universities and the proposed 'centres of excellence'. There is no reference to the critical importance of creating innovation-related human capital via activities that are necessarily located in enterprises and organised by them. Nor is there any suggestion that mobilising and fostering this part of the human capital creation process might need some form of co-ordinated and policy-supported action on a cross-Africa basis.

Along the same lines, nearly all the proposed activities for strengthening knowledge production and technology development are to be undertaken in the upstream institutes and universities. Production enterprises, as users of innovations, are identified as technology-creating co-players in the African innovation system in only one or two instances.

In summary, these parts of the report are entirely consistent with the views in the right-hand column of Table 3 above. They show no recognition of the importance of dispersed innovative activities and capabilities that are deeply embedded in production organisations across the industrial and other sectors of the economy.

(ii) The Policy Component of the Consolidated Plan of Action

The policy-related section of the CPA (Section 4) covered two issues (i) fairly general aspects of S&T policy and (ii) more specific issues about 'building innovation mechanisms'. These actions were organised under six Programmes with a total of 19 projects (or indicative project ideas).

The majority of these – five of the six programmes and sixteen of the nineteen projects – seem to be concerned with strengthening relatively general aspects of S&T policy, including: STI indicators, regional co-operation, public understanding of science and technology, developing a common strategy for biotechnology, and building science and technology capacity.

Only one of the six programmes is concerned specifically with 'building innovation mechanisms'. Within that, only one issue is considered: 'Promoting the Creation of Technology Parks'. The outlined rationale for these parks is largely concerned with: 'the *transition from the conduct of science or research to the application* of scientific knowledge to generate specific product or process innovations' (2006: 62, emphasis added)

In other words, this initiative is essentially driven by interest in applying the outputs of the core upstream part of the STI system – a focus that is reminiscent of the 1970 Manifesto. In contrast there is no reference to any other kind of innovation mechanism that might focus, for example, on (i) fostering innovative activity by enterprises themselves without the umbilical cord to the central organisational location of new knowledge creation, or (ii) strengthening the human capital component of the capabilities of those enterprises to undertake such innovation.

Thus the whole body of this plan for Africa pays almost no attention at all to the two kinds of complementarity that I have emphasised earlier in Section 4.

First, although there are aspects that recognise the international dimensions of national innovation systems, these are almost entirely about cross-country R&D collaboration between centrally organised public institutes. In contrast, the report is almost entirely intra-national when it comes to questions about technology and innovation that are in any case given much more limited attention. In particular, there is nothing at all about how actions might be taken to complement localised innovative activity with the region's huge technology imports that are undertaken mainly by firms and operational government bodies.

Second, there is virtually no recognition of the importance of complementarity between the centralised structure of R&D activities, capabilities and organisations on the one hand and innovation activities and capabilities that are distributed pervasively across the production sectors of the economy on the other. To the very limited extent that this connection is noted, it is seen almost entirely in terms of a one-way linkage through which innovations will somehow be delivered to technology users in the economy.

In summary, this report shows almost no indication of being influenced by any of the more important insights from studies of innovation and innovation capabilities in developing countries over the 40 years since the appearance of the Sussex Manifesto in 1970. Indeed, the core proposals of the *Consolidated Plan of Action* would probably have served very well as an annexe of practical elaborations to the linear, R&D-centred and upstream organisationally focused views of the original Manifesto.

6. CONCLUSIONS: POLICY, IDEAS AND POLITICAL STRUCTURES

The main conclusions from the review in this paper can be drawn at three levels. One is about the practicalities of policy for science, technology and innovation, and in particular it is about shifting policy in directions that have been under-emphasised over the last 40 years in most developing countries, and even totally neglected in some. The second is about ideas, and in particular about perceptions of innovation and innovation capabilities that underpin different approaches to policy. The third is about politics, and in particular about structures of power, interest and influence.

The conclusions in these different areas are of course linked. Ideas about the nature of innovation and innovation processes shape the practicalities of policy about science, technology and innovation; and shifts in policy will not move far if the prevailing and influential ideas in these areas remain those of 40 years ago or earlier. But structures of power, interest and influence also shape policy, and again shifts in policy are unlikely to move far if the prevailing structures benefit from existing patterns of policy. Those structures probably shape ideas as well, and they certainly influence which are absorbed into the dominant policy discourse. Consequently they constitute a potential two-level constraint on shifting the practicalities of policy in new directions.

But those links are not tight and mechanical. They involve elements of flexibility, and hence leave some space for shifting policy practicalities even within the framework of currently dominant ideas and structures of power, interest and influence. The magnitude of that room for manoeuvre is unknown, and in any case it no doubt varies widely between different situations. Consequently I will not discuss here the relationships between the three sets of issues, and will merely try to summarise a few key points about each.

Part of the context for these comments is the record of building innovation capabilities in developing countries over the 40 years since the Manifesto. Unfortunately there is inadequate information to outline that record in a moderately comprehensive way, and even data about the narrow R&D component of innovation capability are fragmentary. Nevertheless, these have been used in another STEPS Background Paper to provide an approximate sketch of what has happened (Ely and Bell 2009: Section 2.1). In summary, the picture is as follows.⁴⁴

For all the countries that were 'developing' in 1970, R&D expenditure rose very sharply between the early 1970s and the 1990s. Their share of the global total had trebled to 10 per cent by 1990 and doubled again to more than 20 per cent by 1999/2000. But this aggregate picture for the whole

⁴⁴ Figures for 1990 and 1999/2000 are based on the UNESCO Institute for Statistics (2004) *Bulletin on Science and Technology Statistics*.

group is misleading because there were highly uneven changes among different sub-groups of countries.

One group, selected Asian NIEs and China, had already overshoot the Manifesto target by 1990 – achieving GERD/GDP ratios that were about three times higher in 1990 than the target of 0.5 per cent for 1980. That increased again by 1999/2000 when this group alone accounted for 13 per cent of the global total and for nearly two-thirds of the developing country total.

The share of the global total accounted for by the Latin American and Caribbean countries had increased by 1990, reaching nearly three per cent. But it then stagnated through the 1990s. Behind this, the GERD/GDP ratio of this group had only reached the Manifesto target of 0.5 per cent in 1990 - ten years late. They had only crept over it to 0.6 per cent after another ten years. But that group is dominated by Brazil with a GERD/GDP ratio approaching 1.0 per cent by the late 1990s. The implication is that, 20 years after the Manifesto target date of 1980, the rest of this group still lagged behind the target. Little appears to have changed since then.

A third group, countries in Africa, had also increased their share of the global total by 1990, though they fell back again during the 1990s. However, African R&D is dominated by South Africa which already had a GERD/GDP ratio of 1.0 per cent by 1990 – a level it has more or less maintained subsequently. The data for the rest of Africa are especially limited, but they suggest that Sub-Saharan countries and the African Arab states had GERD/GDP ratios of around 0.5 and 0.3 per cent in 1990, but that both groups of countries fell back during the 1990s to the Manifesto's 1970 baseline of 0.2 per cent.

Thus, by around 1999/2000 – 20 years after the Manifesto target date – the level of R&D expenditure of 0.5 per cent of GDP had not been reached in large parts of Asia, in much of Latin America and the Caribbean (probably all except Brazil) and in most of Africa (all except South Africa). Fragments of data for subsequent years suggest that little of this pattern has changed, except in India and some of the South East Asian countries.

A further striking feature is that many of these developing countries had a highly imbalanced structure of R&D in terms of the organisations that performed and funded it. Asian NIEs and China had transformed the structure from around 30 per cent performed by business enterprises and 70 per cent by government organisations in the 1970s to around 60-70 per cent by enterprises by the start of the current decade. However most other developing countries had not transformed the structure very far in that direction, and the share accounted for by government still remains around 70-80 per cent in many of them.

POLICY

At a broad level, the policy conclusions I draw from this paper follow from several observations about innovation and innovation capabilities in Section 4.

- Innovation involves a wide heterogeneity of different phenomena (from global novelties to firm-specific improvements).
- Correspondingly, the innovation process involves a wide heterogeneity of activities (not just R&D, but many others – among which design and engineering are particularly important).
- Consequently, innovation capabilities consist of a wide range of different resources, with various types of 'knowledge-asset' at their heart (not just capabilities for R&D in centrally organised institutes, but many others that are distributed pervasively across, and embedded deeply in, production activities and enterprises).

- The creation of the knowledge asset component of those capabilities does not rest solely on education and training in specialised secondary, tertiary and postgraduate institutes. Although that is often an important base, a large additional part of creating such capability occurs in production enterprises.
- But those knowledge assets are qualitatively different from production capabilities and they require explicit investment in particular kinds of training and organised learning (recall, for example, the earlier discussion associated with Figure 1).
- As is well recognised in connection with investment in many other kinds of knowledge asset, the market is a very poor mechanism for ensuring appropriate investment in this area as well (uncertainty, non-appropriability of the full returns, etc.).

Consequently, given that there commonly appear to be high returns to investment in creating those capabilities (e.g. in terms of techno-economic performance measures or as reflected in productivity measures), there are strong grounds for developing policy initiatives focused on strengthening firm-level activities for creating and applying such innovation capabilities. In particular, such policy measures could be concentrated on reversing two major imbalances in the innovation systems of many developing countries:

- (i) The heavy concentration of public policy on fostering innovation capabilities in the form of R&D capabilities organised in central and usually public institutes like R&D centres and universities – *vs*– the very limited policy attention given to strengthening the creation and use of complementary capabilities in production enterprises.
- (ii) The heavy concentration of firms on acquiring technology via imports from advanced economies – *vs*– their very limited investment in creating and using their own complementary innovation capabilities.

In other words, the implications are not just about re-stating the challenge of the original Sussex Manifesto - calling for a massive *increase in the scale* of innovation capabilities in developing countries. It is also about calling for a massive *re-balancing of the structure* of efforts that have been made to build such capabilities over the last 40 years in most of those countries. This scaling up and re-balancing of resource allocation is something to be addressed by national governments and also the donor community.

(i) Complementarity between Centrally Organised R&D Capability and other Forms of Innovation Capability

In principle there are numerous possible policy measures that might help to achieve this re-balancing within a growing total stock of innovation capability. Three general aspects of such measures seem important.

First, what might be possible in principle has not been reflected in what governments have actually implemented in practice. Indeed the array of measures used by governments to foster innovative capability in latecomer firms has been extremely narrow, except for some periods in some countries like Korea, Singapore and China. They have mostly been limited to practices imitated from advanced countries - measures like support for science parks or venture capital, as well as fiscal incentives, grants and subsidised loans for R&D by firms. Such measures are very poorly oriented towards the conditions in most developing countries, and consequently considerable policy experiment and invention is called for.

Second, in pursuing such experimentation it will be important to recognise that the *primary* issue here is not about *linking* central R&D institutes to enterprises – useful as that would be. Nor is it necessarily about R&D at all. It is about innovative capabilities in firms themselves, and these must usually consist of various kinds of non-R&D capability before firms' needs evolve towards R&D.

Moreover, as noted earlier, links from firms to central R&D organisations are much more likely to follow than precede the development of strong innovative capabilities in firms themselves.

Third, particular emphasis on medium-to-large firms as the main targets for such policy measures will usually be important. This is partly because it is often difficult and complicated to strengthen small firms' innovative activities and capabilities, and a considerable number of programmes already exist in many developing countries to strengthen their production capabilities and positions in value chains. It is also because relatively large firms are more able to organise the kinds of activity involved and to act as vehicles for the accumulation of knowledge resources that subsequently diffuse to other, often smaller, firms.

Beyond those generalisations, more detailed comment here is not sensible. However, it might be useful to flag one aspect of a broad approach: the establishment by governments of 'envelope' targets within which to pursue their policy experimentation and invention. These might include, for instance, targets like the following.

For every government \$1 spent next year on R&D activities and capability building, another \$ 'x' should be spent on non-R&D activities and capability strengthening – e.g. on D&E.

So for example if, as in the African *Consolidated Plan of Action*, a national target is set to raise the proportion of GDP spent on R&D towards 1 per cent, so a corresponding target for building and strengthening, say, D&E capabilities should be set at 'x' per cent.

For every government \$1 spent next budget year on innovation activities and capability building in central, public institutes, another \$ 'x' should be spent on such activities and capability strengthening in enterprises

Again, let me illustrate by reference to the African CPA. If as seems to be the case, the intention is to raise expenditure on STI activities and capabilities in central institutes and centres of excellence, the corresponding target here should be to spend the equivalent of 'x' per cent of that on dispersed innovation activities and capabilities in enterprises.

Obviously the appropriate size of 'x' will vary between countries and also between areas of production and technology within countries. Sometimes it will be larger, perhaps much larger, than the comparable level or fraction of expenditure on R&D and central organisations. In other circumstances it might be smaller. But explicit commitments along these lines seem likely to be necessary to help shift policy towards re-balancing and away from merely pursuing expansion.

(ii) Complementarity between Technology Imports and Local Innovation

I outlined earlier in association with Figure 1 the broad character of these complementary activities at the level of technology-importing enterprises. In sectors where high levels and rates of growth of technology imports are expected, policy measures to foster and strengthen such activities could include:

- Support for firm-centred organisational arrangements and training/learning facilities to strengthen the knowledge bases needed by firms *in advance of* technology importing projects – capabilities needed to acquire and absorb knowledge, skill and experience via future technology-importing channels.
- Support for activities involved in the *subsequent acquisition* of additional knowledge and expertise via the technology-importing relationship. Such support might include, for instance, measures to meet some of the costs of seconding local personnel to training and experience acquisition with suppliers, as well as the additional costs incurred by suppliers in deepening such activities beyond what they would normally do. Donors might often be particularly important in

supporting the organisation of such arrangements and in contributing to the necessary financial resources.

- Support, where appropriate, for collaborative arrangements that would link the previous two kinds of activity on a cross-country basis. This might include, for example, cumulatively moving personnel through successive projects in similar areas of technology in different countries, so accelerating the emergence of cohorts of experienced contributors to innovation. They might also include creating firm-based, regional 'centres of excellence' in key areas of expected technology imports in collaborating countries.

The donor community could explore mechanisms to work in such schemes alongside technology exporting companies from their own countries. For example, they might contribute to the costs incurred by those companies in deepening training and learning opportunities beyond their normal practice and requirements.

As with activities to strengthen the complementarity between centralised R&D and other innovation capabilities, it might be useful to set these kinds of activity within the framework of national, and perhaps also regional, policy targets along the lines of the following:

For every \$1 likely to be spent over the next five years on importing design, engineering and similar services, \$ 'x' should be spent on activities (e.g. like those outlined above) in order to strengthen local D&E capabilities.

IDEAS

As summarised earlier in the two parallel columns of Table 3, widely divergent ideas about innovation and innovation capabilities underpin different perspectives on policy in this area; and it is ideas along the lines of the left-hand column in the table that underpin the suggestions about policy outlined immediately above. Consequently, if the discourse about policy in this area is informed by ideas like those in the right-hand column, the practice of policy is unlikely to shift very far in the suggested directions.

But beyond that, these underlying ideas about innovation and innovation capability shape the broad framing of policy discussion, not merely the detailed approaches to policy.

For example, if no distinction is made between production and innovation capabilities as qualitatively different kinds of asset, then industrial growth is seen very largely in terms of the accumulation of the physical capital and human capital components of production capacity. Debate about policy for industrial growth, 'industrial policy', then easily becomes locked into discussion about the merits of governments trying to 'pick winners' in order to accelerate change in the composition of production in terms of different types of industry. One view highlights the disadvantages and probable inefficiencies of this (e.g. Pack and Saggi 2006) and another stresses the merits, as reflected in the earlier historical experience of industrialising economies from the eighteenth to the early twentieth centuries (e.g. Chang 2003). But both sides of this discussion are largely irrelevant for considering policy concerned with strengthening investment in the components of innovation capability – completely different kinds of asset with very substantial differences in the market conditions for investment.

Similarly, everyone agrees that constant improvement in performance in using previously imported technology is important. But if this is thought likely to arise as a simple consequence of learning by doing ongoing industrial production, or if the necessary knowledge assets are thought likely to be created more or less automatically as a by-product from production experience, then policy discussion easily becomes locked into debates about trade policy. One view will argue about the importance of trade protection in providing firms with the opportunities to acquire production

experience. The other will argue for the superior merits of international competition as the source of stimuli and pressures for raising performance in production. But again, both these perspectives on policy are at best marginal to the main issue if performance improvement is the result of specific innovative activity driven by particular kinds of capability that need to be created by investment in particular kinds of knowledge asset. In that case, the issues for debate are about externalities and limited appropriability of the returns to the investment. From there they need to move to questions about inventing types of policy measure that are similar in principle to, but different in detail from, well-known measures like intellectual property protection to stimulate investment in knowledge assets, the returns to which are not fully appropriable by the private investor.

It would be easy to go on from there to suggest that ways must be found to shift the policy discourse in this area from resting on ideas about innovation on the right-hand side of Table 3 (mostly at least 40 years old already) to those on the left-hand side (the product of studies undertaken mostly over the last 40 years). But such a suggestion would be much too simple.

Quite frankly, it is not surprising that those more recent ideas have had limited impact. They are far from convincing in terms of the quality of evidence, results, generalisability, underlying methods, the questions still unanswered (and even unasked), and much else.⁴⁵ The requirement therefore is for a renewal and strengthening of studies in this area. Do the ideas outlined in Section 4 and summarised in the left-hand side of Table 3 stand up to closer and more systematic scrutiny? Do they therefore provide the basis for what is suggested in this paper: a fundamental change in the approach to policy for science, technology and innovation in developing countries in the context of the early decades of the 21st century?

In the meantime, however, there are already some areas where ideas can surely be shifted to create at least some wider space for thinking about new directions of policy.

First, understanding about the nature of innovation seems clear enough for steps to be taken to enable policy analysis to break free of the straightjacket of existing statistical frameworks and distorted 'innovation system' models that identify R&D as the sole contributor to innovation and hence as the sole component of innovation capability. Beyond that, it would be better still to start experimenting with ways of generating data for the kinds of statistical indicator that would illuminate the broad magnitudes and trends of the more important non-R&D components of innovative activity –perhaps focusing initially on simple enquiries and surveys about various kinds of D&E activity.⁴⁶

Second, it is also time to recognise the importance of *interactive* complementarity between R&D-focused innovation capabilities deployed in specialised and centralised organisations on the one hand and other kinds of innovation capability, especially design and engineering-focused capabilities, that are accumulated in and around production activities in the economy.

Third, it is time to end policy discussion about technology imports and localised innovation as alternatives. They are complements. This is well recognised at the level of firms, sectors and economies among the rich countries. It applies just as much to firms, sectors and economies in the developing world. The difference between the two contexts is not about the presence/absence of localised innovative activity; it is about *the kind of* localised innovative activity undertaken, and hence about *the kind of* innovation capability that is created and accumulated.

Finally, in order to explore that issue further, it is time to forget ideas and arguments about how technology imports *inherently and automatically* carry with them associated flows of knowledge, skill and experience that effortlessly spill over into the local context and add to local innovation capabilities. A little of that does happen, but the key issue is that the extent to which it does is highly

⁴⁵ See for example, the discussion in Pack (2005).

⁴⁶ See the companion STEPS Background Paper (Bell 2009) for elaboration on this issue.

variable, and the *potential* flow of such additions to innovative capabilities seems to far exceed the flow that *actually* occurs in the absence of concrete management actions. Recognising at least those ideas would open up the possibility of then asking questions about the factors that influence that variability and whether there are policy measures that might also do so efficiently.

POLITICS, INTERESTS AND INFLUENCE

This final section can be very brief because, as I outlined earlier in Section 4, over the last 40 years there has been almost no analysis of the role of political systems, power structures, interest groups, and bureaucratic processes in shaping policy for science, technology and innovation in developing countries – at least not in the area of industrial technology and innovation. We therefore know little more about these issues than was sketched in the early explorations by Charles Cooper, Amilcar Herrera and Frances Stewart.

We do not even know whether those earlier perceptions point in appropriate directions of questioning, though Cooper's brief comments on the possible role of the scientific community still appear plausible. For example, it seems most unlikely that re-balancing policy along some of the lines sketched above would be enthusiastically endorsed by the established scientific communities and interest groups that currently dominate policy and resource allocation for STI in many developing countries. That scientific community is also an 'R&D community', and it is unlikely to re-balance resource allocation very far away from its own interests and in the direction of non-R&D activities. Changes in governance structures for STI policies may therefore be needed in order to move in the directions suggested.

But that is entirely speculation – or rather, it is a call for much more research to understand these political aspects of the policy process in areas concerned with science, technology and innovation.

ANNEXE 1

SUMMARY REVIEWS OF 'MAINSTREAM' DEVELOPMENT REPORTS

This annexe includes summary reviews of five reports that I describe as 'mainstream development reports'. These are presented in Boxes A1-A4. The first three (Boxes A1 - A3) are relatively recent reports published since 2005. They provide wide-ranging reviews across the board of development issues, including some consideration of questions concerned with innovation. I also include in Box A4 a summary of an earlier broad 'Global' report. This was not specifically about developing countries, but it included an influential analysis of technology and innovation in developing countries that underpinned much of the thinking in the three later reports.

The total package of four reports includes:

Box 1 The Commission on Growth and Development (2008) *The Growth Report: Strategies for Sustained Growth and Inclusive Development*, IBRD/The World Bank

Box 2 Commission for Africa (2005) *Our Common Interest: Report of the Commission for Africa*

Box 3 UN Millennium Project (2005a) *Investing in Development: A practical Plan to achieve the Millennium Development Goals*, Main Report, Earthscan,, London and Sterling, Va.

UN Millennium Project (2005b) *Investing in Development: A practical Plan to achieve the Millennium Development Goals*, Overview, United Nations Development Programme

Box 4 World Economic Forum (2002) *The Global Competitiveness Report 2001-2002*, Oxford University Press, New York

The main purpose of the reviews is to assess the extent to which these reports reflect the insights and understanding about innovation and innovation capabilities in developing countries that has been generated by the body of research on these issues over the 40 years since the publication of the original Sussex Manifesto in 1970. That body of insights and understanding is reviewed in Section 4 of the paper.

BOX A1. THE GROWTH REPORT: STRATEGIES FOR SUSTAINED GROWTH AND INCLUSIVE DEVELOPMENT*

This report examines the experience of countries that have achieved sustained high growth (at least 7 per cent per annum for at least 25 years) since 1950 - a group of only 13. It then reviews a set of 'policy ingredients' for growth. It proceeds to consider the more specific growth possibilities and constraints in selected country contexts (Sub Saharan Africa, Small States and Resource Rich countries), and also in relation to problematic current trends such as global warming and rising intra-country income inequality.

Across all these discussions, the report consistently highlights the importance of technology and knowledge. It also includes in the package of policy ingredients 'measures to promote "innovation" and "imitation"'. These are important because they 'help an economy to learn to do new things – venturing into unfamiliar export industries for example – and to do things in new ways'. (p.34)

However, there is a clear distinction between the kinds of economy where imitation is the key issue and those where promoting innovation is important. Correspondingly there is one group of countries that are creators and inventors of technology and another that acquire it and learn how to use it.

The distinction centres on the aphorism that: 'It is easier to learn something than it is to invent it'. (p.22) Consequently, in principle: 'Latecomers can assimilate new techniques more quickly than the pioneering economies can invent them. That is why poorer countries can "catch up" with richer ones.' (p.18)

It is suggested that empirical reality fits that perspective. Although all the high growth economies rapidly absorbed knowhow, technology and, more generally, knowledge from the rest of the world: 'These economies did not have to originate much of this knowledge, but they did have to assimilate it at a tremendous pace'. (p.41) It is interesting that the report's authors consider this to be a mystery: 'What we do not know – at least not as well as we would like – is precisely how they did it, and how policy makers can hurry the process along. This is an obvious priority for research.' (p.40)

Economies may graduate from those that assimilate but do not originate to those that innovate. However this only occurs after they become Middle Income economies. Moreover these economies may struggle with that transition, failing to maintain their growth momentum as they narrow the gap with high-income countries and as their position in labour-intensive industries is eroded by competition from lower-income economies. However: '**Eventually** those industries fade away. Increasingly growth must spring from knowledge, innovation, and a deeper stock of physical and human capital.' (p.9, emphasis added)

There are several striking features of the report's treatment of technology during the mysterious period of assimilation before this transition occurs.

First, the only mechanism that is explicitly identified as contributing to the massive global flows of knowledge and their assimilation is FDI. In contrast, the huge importance of other mechanisms for active investment in the acquisition and accumulation of knowledge-capital by domestic firms in Japan, Korea, Taiwan, Brazil and India is ignored; as is the hugely heterogeneous experience of FDI as a vehicle for knowledge transfer and assimilation.

Second, there are only two brief mentions of the high growth economies having done anything with the technology they acquired apart from using it. One is a very brief reference to the Japanese textile industry 'improving' British designs and techniques in the late 19th century. The other is a brief qualification to a discussion of the importance of FDI as a channel for knowledge flows to developing countries: 'Japan and Korea were historically much less open to FDI, but they did import and improve upon technology from outside.' (p. 23)

Thus a critically important aspect of the experience of these economies - that 'assimilation' of technology involved the pervasive occurrence of creative change - is almost entirely absent.

Third, although it is noted that it is important for policy makers to anticipate the transition to more innovation-intensive growth, there is no meaningful treatment of what this might involve. For instance, there is no explanation of why so few of the high growth economies (only 6 out of the 13) managed to avoid a falling growth momentum during the middle-income stage. Consequently, there is a very limited

discussion of the factors that influence when economies might make this graduation from assimilation to innovation. Indeed there is no treatment of the timescales involved in the transition process, and consequently no recognition of the long, multi-decade periods required for gradual investment in, and accumulation of, capabilities to innovate in increasingly significant ways.

Equally interesting are several specific situations in which innovation in developing countries, even technology more generally in some cases, seems to be thought irrelevant. These include (i) resource-rich countries with production and trade concentrated in resource based industries and products, (ii) contexts of high income inequality and poverty; and (iii) the context of global warming.

- (i) Neither innovation nor technology is mentioned in relation to the problems of resource-rich countries. But more generally the discussion of the resource-rich problematique is not connected to the discussion of the importance of change in the sectoral structure of economies; and neither of these issues is linked to the discussion of the slowing growth rates of middle-income economies – despite the fact that the resource-rich, Latin American countries with slow rates of structural change are specifically identified as falling into this growth decelerating group (p. 82-83). So, with no identification of that nexus between slow growth, low structural change and high concentration on resource-intensive production and trade, it is not surprising that there is no discussion of the ways in which routes out of the nexus might depend on the role of innovation capabilities to support entrepreneurial search for, and entry into, new areas of comparative advantage.
- (ii) Technological change is not mentioned in connection with the trend of rising intra-country income inequality. But it appears to be seen as an unavoidable cause of the trend, along with shifting relative prices and globalization, and there is no discussion about whether or how this particular direction of technological change might be altered. Beyond that, there seems to be absolutely no perception that anything to do with innovation within developing countries themselves has any relevance to the issue. That seems particularly clear in the discussion about growth challenges in Sub-Saharan Africa. Technology is mentioned in a long list of components of long-term growth strategies. This is in connection with efforts to increase the productivity and output of agriculture in the region. But these efforts are to be achieved with the help of 'external resources and technology', and the list includes no mention of the possibility that 'internal technology', let alone 'internal innovation', might have anything to do with meeting the challenge.
- (iii) In connection with global warming the report highlights the impossibility of combining continuing growth with constraining climate change. It sets aside the adaptation response to that impasse, so by-passing the huge diversity of innovation-related adaptation issues that will arise in poor countries. However in discussing the mitigation response it draws the technology rabbit out of the hat: '[...] technology is the key to accommodating developing country and global growth. We need to lower the costs of mitigation [...] For that we need new knowledge.' (p.86)

It is not immediately apparent where the necessary innovative activity is to be located. But the summarising *Overview* of the report makes this fairly evident. When it comments on the apparent growth vs climate change impasse:

'Technology is the answer. **Advanced economies** should promote the creation of new techniques for cutting carbon and saving energy [...] That is the only way developing countries can grow rapidly without subjecting the world to potentially catastrophic global warming.' (p.10)

This seems to be about creating technology in the advanced economies, and there is no mention of the possibility that those economies might also promote such creation of techniques in developing countries. But, given the report's wider perspective on the irrelevance of innovation in those countries, it seems unlikely that this was the intention.

* The Commission on Growth and Development (2008)

BOX A2. OUR COMMON INTEREST: REPORT OF THE COMMISSION FOR AFRICA*

Innovation seems at first sight to be an important topic in this report. The term appears nearly thirty times. However, in more than one-third of these instances it is used in a very general and inconsequential way to refer to a broad characteristic of society that will be positively affected by such things as better governance or improved education – no doubt true, but not very illuminating about the activity itself.

Among the more significant comments, the great majority (two-thirds) share a common perspective. The idea of innovation is immediately associated with activities like 'research' and 'scientific discovery' and with organisations like universities, research institutes, regional 'centres of excellence' and 'innovation hubs'. In other words the primary focus is on formally organised and largely public organisations at the 'upstream' end of an innovation process that is conceived in linear terms. Essentially, much like the Sussex Manifesto in 1970, these actors and activities are at one end of a pipeline that will deliver at least the main ingredients for innovation – if not complete, 'ready-to-use' innovations themselves.

A large part of this emphasis on science and research focuses on agriculture, in connection with which the array of organisations is usually expanded to include the suppliers of public and private 'extension' services. The international community is urged to fund a major growth in these activities and it should do so by funding regional research organisations, universities and centres of excellence, in addition to the CGIAR research centres (p.238). There is a brief comment that this linear system should be 'driven by the needs of farmers', and also a suggestion that 'Rejuvenation of agriculture should include timely institutional innovations appropriate to each locality involving smallholders and other stakeholder'. But it is not clear whether the 'institutional innovation' applies specifically to the research-extension system, and there is certainly no comment about the practicalities of what that might consist of, or about how the system might be 'driven by farmers needs'. These neglected issues seem particularly important in the light of aspects of the suggested organisational arrangements that pull in the opposite direction – towards the centralisation of activities in a limited number of regional centres of excellence, and towards an essentially hierarchical structure in which such centres will 'sit at the apex of the educational and research system in each region of sub-Saharan Africa...' (p.138)

Nevertheless there are brief glimpses of a different perspective. About one-third of the comments about innovation are associated with activities occurring much more immediately in the context of production. Some of these are about mainly organisational forms of innovation in activities producing public services – innovation in the organisation of teacher training in Malawi that raised the rate of supply and lowered the cost (p.186), innovation to improve the effectiveness of treatment and care in the health system (p.190), innovation that will equip women and other vulnerable groups with the capacity to reduce their poverty – and more generally to ensure that services reach the poorest and excluded (p.213). Others are more about innovation in private enterprises in industry (p.276) where reference to the cited report makes it clear that the issue is about the technological upgrading of products and processes.

But these observations about innovation that is embedded in production activities and organisations consist of very brief remarks, with no comments about what it actually consists of or how it might be fostered. What is almost entirely missing, therefore, is any connection to the idea that widely dispersed innovation capabilities may be centrally important to a 'Common Interest' in Africa – an essential basis for implementing innovation across the enormous heterogeneity of African agriculture and health care systems, plus the change in this heterogeneity that is likely to arise as a result of climate change; for designing and implementing innovation in industry and in the construction of African infrastructure, or for supporting the entrepreneurial activities needed to change the sectoral structure of African economies.

A more striking reflection of this imbalance is that none of the comments noted above - not even the references to innovation in association with science, research and so forth - appear in the proposals for concrete action put forward in the twelve pages of recommendations. Only the organisations at the

front end of the pipeline are mentioned, and the more centralised of these at the 'apex' of African research systems carry off the lion's share of the funding – it is recommended that the international community should commit: US\$500 million 'to revitalize Africa's institutions of higher education' and six times as much (US\$3 billion) to develop 'centres of excellence in science and technology... (p. 67)

* Commission for Africa (2005)

BOX A3. INVESTING IN DEVELOPMENT: A PRACTICAL PLAN TO ACHIEVE THE MILLENNIUM DEVELOPMENT GOALS *

The Millennium Project included a Task Force on Science, Technology and Innovation that produced a report on *Innovation: Applying Knowledge in Development*. However, the comments in this Box are not about that specialised analysis of science, technology and innovation. They focus on the way innovation is treated in the overall reports on the project – both the main report (MR) and the Overview report (OR).

Although these reports rarely use the term innovation, except when referring to the 'I' within S, T & I, they nevertheless offer two apparently contradictory perspectives on the significance of innovative activity in developing countries. One perspective dismisses it as largely irrelevant; but the other suggests actions that seem to be intended to foster it or at least to foster science and technology - which might not be the same thing.

Perspective 1. This is evident in a strand of argument that takes off from a clear assertion:

'Throughout, we stress that the specific technologies for achieving the Goals are known. What is needed is to apply them at scale.' (OR p.2)

Thus there would appear to be no need for innovation - at least not as an activity that has anything to do with creating new technologies and achieving the Millennium Development Goals.

This idea is associated with a clear distinction in the main report between two kinds of economy: (i) poor countries with low levels of innovation because they are too poor to invest in science and technology, and (ii) knowledge-based and innovation-based economies that enjoy sustained growth (p.35). The former constitute 'technology importers' and the latter are 'technology innovators and exporters' (p.45). Korea and Taiwan are cited as examples of economies that made the transition from the one category to the other, *after* they had reached relatively high-income levels in the mid-1980s. It is therefore only the middle-income countries that are designated as the kinds of economy that should start taking action to make this transition – e.g. by developing 'a growing capacity in science and technology' (p.45). The Low-income countries that are too poor to invest in science and technology can presumably proceed with development by continuing to act as technology importers, and they need not bother with ideas about innovation.

The practical implications of this perspective are apparent in two important Appendices to the MR that summarise 'all policies and interventions' following from the overall Millennium Project. These lists of concrete actions are organised in two ways: under seven 'areas' and ten 'targets'. The actions compiled under 128 headings in the list that is organised as 'interventions by area' are particularly illuminating.

Among the seven areas, one is specifically concerned with interventions in science, technology and innovation. This includes only four of the 128 action headings. The other six areas and 124 headings are concerned with investment in broad segments of development activity: rural development, urban development and slum upgrading, the health system, education, gender equality, environmental sustainability. In these areas the dominant type of action is about using and implementing what is known and available.

- A great deal of the action is about 'the provision of' (or fostering the sale of) various kinds of existing goods and services: fertilisers, microcredit services, balanced school meals, appropriate cooking stoves, diesel generators and solar home systems, machinery for food processing, water supply standpipes and boreholes, export processing zones, informal educational opportunities for adult literacy, and telecommunications infrastructure.
- A similarly large proportion of the interventions are about 'constructing' and 'maintaining' various kind of infrastructure, and this is the context in which actions like 'upgrading' and 'rehabilitation' are identified – e.g. urban roads, trunk infrastructure, storm drainage, electric power capacity.
- 'Technology' is mentioned hardly at all, and then only in connection available technology options (e.g. in sanitation systems) between which 'proper' choices should be made. Technology is referred to more often in the list of interventions by targets, but that is almost entirely in connection with using,

investing in, and providing access to information and communication technology.

Obviously these kinds of use, application, operation, implementation, provision and construction of known and available technologies in both their 'hard' and organisational forms are centrally important to achieving the goals aimed for in the Millennium Project.

But, in principle, so also are issues about changing, adapting, shaping and creating technology. Indeed, leaving aside the possible importance of developing 'new' technologies, it is arguable that the creative shaping and improvement of known technologies has a pervasive influence on the extent and diversity of situations in which they can be applied, on the efficiency with which they can be operated, and on the rate at which they can be diffused. However, it is striking that very little of such a dynamic, creative and innovation-centred perspective is reflected in the long list of interventions in the six main areas.

- The term innovation does not arise; and ideas about innovation, as reflected in interventions intended to 'develop' new forms of technology or organisational arrangement arise in very few instances, such as the development of water management techniques.
- Innovation in the form of action to 'modify' or 'improve' existing forms of technology or organisation appears only slightly more frequently – e.g. the provision of improved varieties of crops, increasing the efficiency of cropping systems in connection with the management of freshwater resources, incremental improvements to housing, or the design of agricultural subsidy programs to prevent overuse of forestry and fishery resources.
- Action concerned with research is identified only two or three times – concerned with agriculture (in general), nutrition (bio-fortification) and health (orienting global research towards appropriate medicines for developing countries).
- Although some of the organisational recommendations in the body of the main report (and also in the OR) are concerned with (i) promoting business opportunities in science and technology and (ii) using infrastructure development projects as vehicles for strengthening technological and managerial capabilities, these brief glimpses of innovative activity and capabilities that are embedded in areas of production vanish from the headline recommendations for action.

In contrast to this sparse consideration of any form of innovation in the six main "areas" of development, it is perhaps symbolically significant that almost all the interventions concerned explicitly with science, technology and innovation are locked up inside their own, insulated "area". But this takes us to the second perspective on innovation and innovation capabilities.

Perspective 2. This strand of argument also starts from a clear assertion – but one that seems at first sight to contradict the assertion underpinning Perspective 1.

SUSTAINABLE MDG-BASED STRATEGIES REQUIRE THE BUILD UP OF INDIGENOUS INSTITUTIONS AND SKILLS TO ADVANCE SCIENCE, TECHNOLOGY AND INNOVATION. (OR P.31)

Consequently it is argued that:

Any strategy to meet the Goals requires a special global effort to build scientific and technological capacities in the poorest countries, both to help drive economic development and to help forge solutions to developing countries own scientific challenges. (OR p. 49)

However, the main funding consequences flowing from this are identified narrowly in terms of finance for research – though this is spread quite broadly across agriculture (including tripling the current CGIAR budget), public health, energy technologies and climate change. Some of the associated organisational implications in the OR are similar to those noted in the specialised STI 'area' in Appendix 1 to the main report: Those are essentially about setting up or extending centralised S&T organisations - an independent body to provide scientific advice and technology forecasting to policymakers, centres of excellence for scientific research, research at universities, and science parks and incubators.

Thus, the perspective that takes a more positive view of innovation and innovation capabilities finishes up concentrating on (i) building and strengthening organisations at the upstream end of a linear innovation 'pipeline' (roughly as in the Sussex Manifesto nearly 40 years earlier), and (ii) developing policy bodies concerned with science and technology (roughly as pursued by UNESCO in the 1970s and 1980s).

* UN Millennium Project (2005a, 2005b)

BOX A4. THE GLOBAL COMPETITIVENESS REPORT 2001-2002 *

This *Global Competitiveness Report* (GCR) was published shortly after the terrorist attacks in the US on September 11, 2001, and most of its content consists of assessments of the uncertainty surrounding various aspects of global competitiveness in different regions of the world following those events. But it also includes a paper by John McArthur and Jeffrey Sachs about the 'Stages of Economic Development' and the association of these with features of the 'Technological Advancement' of economies. This is important because it provides what appears to be a large part of the intellectual basis for what I have called 'mainstream' ideas about innovation and innovation capabilities in developing countries, as reflected in Boxes 1-3 earlier. This connection is reinforced by the fact that Jeffrey Sachs, a contributing author of the 'Stages' paper in this GCR, was also the architect of the Millennium Project and its main reports reviewed earlier in Box 3.

The basic idea about stages of development in the GCR derives from the tripartite classification that Michael Porter had offered about ten years earlier in his widely read *Competitive Advantage of Nations* (1990). With reference to the relative importance of the four points of his celebrated 'diamond' depicting the main sources of competitive advantage, Porter had distinguished three stages through which economies progressed (pp.545-556).

- The *factor-driven stage* - when economies depend on the basic factors of production – natural resources and/or abundant and inexpensive semi-skilled labour. Competition rests solely on price, while technology is sourced largely from other nations and not created. Apparently, 'Nearly all developing nations are at this stage, as are virtually all centrally planned economies', along with prosperous nations such as Australia and Canada.
- The *investment-driven stage* - when economies depend on aggressive investment in modern, efficient, and often large-scale facilities equipped with the best technology available on global markets. It is interesting that, in contrast to later derivatives of this broad tripartite scheme, Porter specifically highlights that at this stage 'foreign technology and methods are *not just applied but improved upon*' (original emphasis) as firms begin developing their own refinements including their own product models. Increasingly skilled workers and technicians are therefore needed not only to operate sophisticated facilities but also to provide the 'internal capability to assimilate and improve technology'. Apparently 'Very few developing nations ever make this stage', and in the post-war period only Japan and Korea have succeeded, while Taiwan, Singapore, Hong Kong Spain and perhaps Brazil were (in 1990) showing signs of achieving it.
- The *innovation-driven stage* - when 'firms not only appropriate and improve technology and methods from other nations but *create* them'. They push the state of the art in product and process technology, marketing, and other aspects of competing in differentiated industry segments. Also the capacity to innovate opens up new industries.

These categories are picked up in the GCR where they are associated with the common classification of economies at different income levels.

- Factor-driven economies are identified as the Low Income economies (i.e. more narrowly than by Porter);
- Investment-driven economies are the Middle Income (plus some High Income) economies;
- Innovation-driven economies are a large sub-set of the High Income economies.

A sharp, innovation-related divide is drawn between the first two and the third of these categories. This rests on the distinction between: (a) 'creating a truly new technology', and (b) 'adopting (and adapting) a technology that has been developed abroad'.

'The first process is called *technological innovation*; the second, *technological diffusion*.' (p.29)

Economies engaging in the former constitute the world's *core economies* and those engaged in the latter are *non-core economies*. These terms are used to describe: 'the critical division in today's world economy between the innovating and non-innovating economies'.

There is brief mention of the idea that diffusion may involve not only the assimilation of foreign technology but also 'the capacity to improve on it' (p.18). But that, and even the idea of adapting technology, is usually absent from comments about the non-innovating stages of economic development. More often the discussion of the different sides of the world's critical division is reduced to simple contrasts between such things as 'innovation and technology transfer'; while movement across the divide is described simply as 'transition from a technology-importing economy to a technology generating economy' (p.17) or as a 'transition from technological adoption to innovation' (p 38).

An empirical basis for the distinction between core and non-core is constructed. This has two parts, both based simply on the number of US utility patents per year. One part consists of a threshold of 15 per year on average through the 1980s, and this identifies a core group of 18 OECD economies. The second part consists of the same threshold for the year 2000. This identifies a small group of economies that had crossed the threshold between 1990 and 2000 and are included in the core (Taiwan, Iceland, Ireland, Hong Kong, Singapore and Korea).

Thus the core group consists of those economies that not only generate a sufficient number of patentable, new-to-the world innovations, but are sufficiently involved in trade with the US in the relevant goods to justify the cost of taking out patents there. Outside that group, questions about innovation and innovation capabilities are largely irrelevant – except for the small number of upper middle income economies that might expect to make the transition to the elite innovator group in the next decade or so.

A broader type of indicator, constructed in slightly different ways to assess the technological performance of core and non-core economies, confirms this impression. The version for the non-core economies includes a combination of innovation, technology transfer and ICT sub-indexes. The innovation sub-index, accounts for a weight of only one-eighth of the total index, and it includes the US patent-based measure and an indicator of tertiary enrolments (plus a small weight given to responses to an 'Executive Opinion Survey' about such things as R&D and the importance of 'continuous innovation for your business'). Beyond that, no other aspect of the technology index attempts to reflect any aspect of activities or capabilities concerned with creating, improving, shaping or adapting technology. The technology transfer sub-index rests on a combination of (a) executive opinion survey responses to a single question about whether FDI is an important source of new technology, and (b) a measure derived from the significance of manufactured exports. The ICT-related sub-index refers simply to the extent to which various types of equipment are installed, plus responses to survey questions about the regulation, promotion and use of ICTs. In other words, as the US patent score is irrelevant for nearly all of the Middle- and Low-income economies, the overall Technology Index is almost entirely a reflection of various aspects of using and operating technology.

* World Economic Forum (2002)

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