THE NEW PRODUCTION OF KNOWLEDGE

The Dynamics of Science and Research in Contemporary Societies

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Contents

Introduction

This volume is devoted to exploring changes in the mode of knowledge production in contemporary society. Its scope is broad, concerned with the social sciences and the humanities as well as with science and technology, though fewer pages are given to the former than to the latter. A number of attributes have been identified which suggest that the way in which knowledge is being produced is beginning to change. To the extent that these attributes occur across a wide range of scientific and scholarly activity, and persist through time they may be said to constitute trends in the way knowledge is produced. No judgement is made as to the value of these trends – that is, whether they are good and to be encouraged, or bad and resisted – but it does appear that they occur most frequently in those areas which currently define the frontier and among those who are regarded as leaders in their various fields. Insofar as the evidence seems to say that most of the advances in science have been made by 5 per cent of the population of practising scientists, these trends, because they seem to involve the intellectual leaders, probably ought not to be ignored.

It is the thesis of this book that these trends do amount, not singly but in their interaction and combination, to a transformation in the mode of knowledge production. The nature of this transformation is elaborated for science, in Chapter 1; for technology in Chapter 2; in Chapter 4 for the humanities; and for the social sciences throughout the text. The transformation is described in terms of the emergence alongside traditional modes of knowledge production that we will call Mode 2. By contrast with traditional knowledge, which we will call Mode 1, generated within a disciplinary, primarily cognitive, context, Mode 2 knowledge is created in broader, transdisciplinary social and economic contexts. The aim of introducing the two modes is essentially heuristic in that they clarify the similarities and differences between the attributes of each and help us understand and explain trends that can be observed in all modern societies. The emergence of Mode 2, we believe, is profound and calls into question the adequacy of familiar knowledge producing institutions, whether universities, government research establishments, or corporate laboratories.

Before discussing the attributes of Mode 2 and how they differ from Mode 1, it is necessary to call attention to a difficulty that is inherent in any attempt to describe a new mode of knowledge production. To the extent that a particular way of producing knowledge is dominant, all

other claims will be judged with reference to it. In the extreme case, nothing recognisable as knowledge can be produced outside of the socially dominant form. This was the situation that confronted the early practitioners of the 'new' science when they confronted the Aristotelian Peripatetics at the beginning of the Scientific Revolution. It seems to be a recurrent historical pattern that intellectual innovations are first described as misguided by those whose ideas are dominant, then ignored and, finally, taken over by original adversaries as their own invention. Part of the explanation of this phenomenon derives from the fact that it is necessary to begin by describing the characteristics of the new in terms of the old. A further difficulty may be expected when the new mode is growing out of the existing one as is the case here. While it is always desirable to be clear about the terms being used, it is not possible at this early stage when so much is in flux to distinguish the two modes unequivocally. This is not a serious weakness, however, for if the new mode became a permanent feature on the social landscape a new vocabulary would emerge to handle the situation. And, of course, afterwards one may wonder what all the fuss was about. Hopefully, a more felicitous term will eventually be found to describe Mode 2, but it is important to keep in mind that a new name has been chosen because conventional terms – such as applied science, technological research, or research and development – are inadequate.

The problem of language is particularly difficult when trying to describe the nature of Mode 2 in areas where natural science is involved. In Western cultures, particularly, the terms science and knowledge are often used interchangeably or combined to form scientific knowledge. In the early phases of the scientific revolutions it was important to distinguish scientific from non-scientific forms of knowledge. A history of knowledge production since the seventeenth century could be written in terms of the efforts of the proponents of previously non-scientific forms of knowledge production to gain recognition as scientific. In Western cultures to be involved in non-scientific knowledge production is to place oneself beyond the pale, so that there is, today, a distinct sense of social isolation associated with participation in a non-scientific activity. But, the term scientific in this context already implies a distinct form of knowledge production. Its ideal is Newtonian empirical and mathematical physics.

In this essay, the term Mode 1 refers to a form of knowledge production – a complex of ideas, methods, values, norms – that has grown up to control the diffusion of the Newtonian model to more and more fields of enquiry and ensure its compliance with what is considered sound scientific practice. Mode 1 is meant to summarise in a single phrase the cognitive and social norms which must be followed in the production, legitimation and diffusion of knowledge of this kind. For many, Mode 1 is identical with what is meant by science. Its cognitive and social norms determine what shall count as significant problems, who shall be allowed to practise science and what constitutes good science. Forms of practice which adhere to these rules are by definition scientific while those that violate them are not. It is partly for these reasons that whereas in Mode 1 it is conventional to speak of science and scientists it has been necessary to use the more general terms knowledge and practitioners when describing Mode 2. This is intended merely to highlight differences not to suggest that practitioners of Mode 2 are not behaving according to the norms of scientific method. It is our contention that there is sufficient empirical evidence to indicate that a distinct set of cognitive and social practices is beginning to emerge and these practices are different from those that govern Mode 1. The only question may be whether they are sufficiently different to require a new label or whether they can be regarded simply as developments that can be accommodated within existing practices. The final answer to this question depends partly on acquiring more data and partly on how Mode 1 adapts to changing conditions in the economic and political environment.

Changes in practice provide the empirical starting point of this enquiry. These changes appear in the natural and social sciences but also in the humanities. They can be described in terms of a number of attributes which when taken together have sufficient coherence to suggest the emergence of a new mode of knowledge production. Analytically the set of attributes is used to allow the differences between Mode 1 and Mode 2 to be specified with some clarity. To summarise using terms which will be explored more fully below: in Mode 1 problems are set and solved in a context governed by the, largely academic, interests of a specific community. By contrast, Mode 2 knowledge is carried out in a context of application. Mode 1 is disciplinary while Mode 2 is transdisciplinary. Mode 1 is characterised by homogeneity, Mode 2 by heterogeneity. Organisationally, Mode 1 is hierarchical and tends to preserve its form, while Mode 2 is more heterarchical and transient. Each employs a different type of quality control. In comparison with Mode 1, Mode 2 is more socially accountable and reflexive. It includes a wider, more temporary and heterogeneous set of practitioners, collaborating on a problem defined in a specific and localised context.

Some Attributes of Knowledge Production in Mode 2

Knowledge Produced in the Context of Application

The relevant contrast here is between problem solving which is carried out following the codes of practice relevant to a particular discipline and problem solving which is organised around a particular application. In the

former, the context is defined in relation to the cognitive and social norms that govern basic research or academic science. Latterly, this has tended to imply knowledge production carried out in the absence of some practical goal. In Mode 2, by contrast, knowledge results from a broader range of considerations. Such knowledge is intended to be useful to someone whether in industry or government, or society more generally and this imperative is present from the beginning. Knowledge is always produced under an aspect of continuous negotiation and it will not be produced unless and until the interests of the various actors are included. Such is the context of application. Application, in this sense is not product development carried out for industry and the processes or markets that operate to determine what knowledge is produced are much broader than is normally implied when one speaks about taking ideas to the marketplace. None the less, knowledge production in Mode 2 is the outcome of a process in which supply and demand factors can be said to operate, but the sources of supply are increasingly diverse, as are the demands for differentiated forms of specialist knowledge. Such processes or markets specify what we mean by the context of application. Because they include much more than commercial considerations, it might be said that in Mode 2 science has gone beyond the market! Knowledge production becomes diffused throughout society. This is why we also speak of socially distributed knowledge.

Research carried out in the context of application might be said to characterise a number of disciplines in the applied sciences and engineering – for example, chemical engineering, aeronautical engineering or, more recently, computer science. Historically these sciences became established in universities but, strictly speaking, they cannot be called applied sciences, because it was precisely the lack of the relevant science that called them into being. They were genuinely new forms of knowledge though not necessarily of knowledge production because, they too, soon became the sites of disciplinary-based knowledge production in the style of Mode 1. These applied disciplines share with Mode 2 some aspects of the attribute of knowledge produced in the context of application. But, in Mode 2 the context is more complex. It is shaped by a more diverse set of intellectual and social demands than was the case in many applied sciences while it may give rise to genuine basic research.

Transdisciplinarity

Mode 2 does more than assemble a diverse range of specialists to work in teams on problems in a complex applications oriented environment. To qualify as a specific form of knowledge production it is essential that enquiry be guided by specifiable consensus as to appropriate cognitive and social practice. In Mode 2, the consensus is conditioned by the context of application and evolves with it. The determinants of a potential solution involve the integration of different skills in a framework of action but the consensus may be only temporary depending on how well it conforms to the requirements set by the specific context of application. In Mode 2 the shape of the final solution will normally be beyond that of any single contributing discipline. It will be transdisciplinary.

Transdisciplinarity has four distinct features. First, it develops a distinct but evolving framework to guide problem solving efforts. This is generated and sustained in the context of application and not developed first and then applied to that context later by a different group of practitioners. The solution does not arise solely, or even mainly, from the application of knowledge that already exists. Although elements of existing knowledge must have entered into it, genuine creativity is involved and the theoretical consensus, once attained cannot easily be reduced to disciplinary parts.

Second, because the solution comprises both empirical and theoretical components it is undeniably a contribution to knowledge, though not necessarily disciplinary knowledge. Though it has emerged from a particular context of application, transdisciplinary knowledge develops its own distinct theoretical structures, research methods and modes of practice, though they may not be located on the prevailing disciplinary map. The effort is cumulative, though the direction of accumulation may travel in a number of different directions after a major problem has been solved.

Third, unlike Mode 1 where results are communicated through institutional channels, the results are communicated to those who have participated in the course of that participation and so, in a sense, the diffusion of the results is initially accomplished in the process of their production. Subsequent diffusion occurs primarily as the original practitioners move to new problem contexts rather than through reporting results in professional journals or at conferences. Even though problem contexts are transient, and problem solvers highly mobile, communication networks tend to persist and the knowledge contained in them is available to enter into further configurations.

Fourth, transdisciplinarity is dynamic. It is problem solving capability on the move. A particular solution can become the cognitive site from which further advances can be made, but where this knowledge will be used next and how it will develop are as difficult to predict as are the possible applications that might arise from discipline-based research. Mode 2 is marked especially but not exclusively by the ever closer interaction of knowledge production with a succession of problem contexts. As with discoveries in Mode 1 one discovery may build upon another but in Mode 2, the discoveries lie outside the confines of any particular discipline and practitioners need not return to it for validation. New knowledge produced in this way may not fit easily into any one of the disciplines that contributed to the solution. Nor may it be easily referred to particular disciplinary institutions or recorded as disciplinary contributions. In Mode

2, communications in ever new configurations are crucial. Communication links are maintained partly through formal and partly through informal channels.

Heterogeneity and Organisational Diversity

Mode 2 knowledge production is heterogeneous in terms of the skills and experience people bring to it. The composition of a problem solving team changes over time as requirements evolve. This is not planned or coordinated by any central body. As with Mode 1, challenging problems emerge, if not randomly, then in a way which makes their anticipation very difficult. Accordingly, it is marked by:

1 An increase in the number of potential sites where knowledge can be created; no longer only universities and colleges, but non-university institutes, research centres, government agencies, industrial laboratories, think-tanks, consultancies, in their interaction.
2 The linking together of sites in a variety of ways – electronically, organisationally, socially, informally – through functioning networks of communication.
3 The simultaneous differentiation, at these sites, of fields and areas of study into finer and finer specialities. The recombination and reconfiguration of these subfields form the bases for new forms of useful knowledge. Over time, knowledge production moves increasingly away from traditional disciplinary activity into new societal contexts.

In Mode 2, flexibility and response time are the crucial factors and because of this the types of organisations used to tackle these problems may vary greatly. New forms of organisation have emerged to accommodate the changing and transitory nature of the problems Mode 2 addresses. Characteristically, in Mode 2 research groups are less firmly institutionalised; people come together in temporary work teams and networks which dissolve when a problem is solved or redefined. Members may then reassemble in different groups involving different people, often in different loci, around different problems. The experience gathered in this process creates a competence which becomes highly valued and which is transferred to new contexts. Though problems may be transient and groups short-lived, the organisation and communication pattern persists as a matrix from which further groups and networks, dedicated to different problems, will be formed. Mode 2 knowledge is thus created in a great variety of organisations and institutions, including multinational firms, network firms, small hi-tech firms based on a particular technology, government institutions, research universities, laboratories and institutes as well as national and international research programmes. In such environments the patterns of funding exhibit a similar diversity, being assembled from a variety of organisations with a diverse range of requirements and expectations which, in turn, enter into the context of application.

Social Accountability and Reflexivity

In recent years, growing public concern about issues to do with the environment, health, communications, privacy and procreation, and so forth, have had the effect of stimulating the growth of knowledge production in Mode 2. Growing awareness about the variety of ways in which advances in science and technology can affect the public interest has increased the number of groups that wish to influence the outcome of the research process. This is reflected in the varied composition of the research teams. Social scientists work alongside natural scientists, engineers, lawyers and businesspeople because the nature of the problems requires it. Social accountability permeates the whole knowledge production process. It is reflected not only in interpretation and diffusion of results but also in the definition of the problem and the setting of research priorities. An expanding number of interest, and so-called concerned, groups are demanding representation in the setting of the policy agenda as well as in the subsequent decision making process. In Mode 2 sensitivity to the impact of the research is built in from the start. It forms part of the context of application.

Contrary to what one might expect, working in the context of application increases the sensitivity of scientists and technologists to the broader implications of what they are doing. Operating in Mode 2 makes all participants more reflexive. This is because the issue on which research is based cannot be answered in scientific and technical terms alone. The research towards the resolution of these types of problem has to incorporate options for the implementation of the solutions and these are bound to touch the values and preferences of different individuals and groups that have been seen as traditionally outside of the scientific and technological system. They can now become active agents in the definition and solution of problems as well as in the evaluation of performance. This is expressed partly in terms of the need for greater social accountability, but it also means that the individuals themselves cannot function effectively without reflecting – trying to operate from the standpoint of – all the actors involved. The deepening of understanding that this brings, in turn, has an effect on what is considered worthwhile doing and, hence, on the structure of the research itself. Reflection of the values implied in human aspirations and projects has been a traditional concern of the humanities. As reflexivity within the research process spreads, the humanities too are experiencing an increase in demand for the sorts of knowledge they have to offer.

Traditionally, this has been the function of the humanities, but over the years the supply side – departments of philosophy, anthropology, history

of such reflexivity has become disconnected from the demand side – that is from businesspeople, engineers, doctors, regulatory agencies and the larger public who need practical or ethical guidance on a vast range of issues (for example, pressures on the traditional humanities for culturally sensitive scenarios, and on legal studies for an empirically grounded ethics, the construction of ethnic histories, and the analysis of gender issues).

Quality Control

Criteria to assess the quality of the work and the teams that carry out research in Mode 2 differ from those of more traditional, disciplinary science. Quality in Mode 1 is determined essentially through the peer review judgements about the contributions made by individuals. Control is maintained by careful selection of those judged competent to act as peers which is in part determined by their previous contributions to their discipline. So, the peer review process is one in which quality and control mutually re-enforce one another. It has both cognitive and social dimensions, in that there is professional control over what problems and techniques are deemed important to work on as well as who is qualified to pursue their solution. In disciplinary science, peer review operates to channel individuals to work on problems judged to be central to the advance of the discipline. These problems are defined largely in terms of criteria which reflect the intellectual interests and preoccupations of the discipline and its gatekeepers.

In Mode 2 additional criteria are added through the context of application which now incorporates a diverse range of intellectual interests as well as other social, economic or political ones. To the criterion of intellectual interest and its interaction, further questions are posed, such as 'Will the solution, if found, be competitive in the market?' 'Will it be cost effective?', 'Will it be socially acceptable?' Quality is determined by a wider set of criteria which reflects the broadening social composition of the review system. This implies that 'good science' is more difficult to determine. Since it is no longer limited strictly to the judgements of disciplinary peers, the fear is that control will be weaker and result in lower quality work. Although the quality control process in Mode 2 is more broadly based, it does not follow that because a wider range of expertise is brought to bear on a problem that it will necessarily be of lower quality. It is of a more composite, multidimensional kind.

The Coherence of Mode 2

These attributes, while not present in every instance of Mode 2, do when they appear together have a coherence which gives recognisable cognitive and organisational stability to the mode of production. Just as in Mode 1

cognitive and social norms are adjusted to one another and produce disciplinary knowledge, so in Mode 2 new norms are emerging that are appropriate to transdisciplinary knowledge. In all kinds of knowledge production, individual and collective creativity find themselves in a varying relationship of tension and balance. In Mode 1 individual creativity is emphasised as the driving force of development and quality control operating through disciplinary structures organised to identify and enhance it, while the collective side, including its control aspects, is hidden under the consensual figure of the scientific community. In Mode 2 creativity is mainly manifest as a group phenomenon, with the individual's contribution seemingly subsumed as part of the process and quality control being exercised as a socially extended process which accommodates many interests in a given application process. Just as in Mode 1 knowledge was accumulated through the professionalisation of specialisation largely institutionalised in universities, so in Mode 2 knowledge is accumulated through the repeated configuration of human resources in flexible, essentially transient forms of organisation. The loop from the context of application through transdisciplinarity, heterogeneity, organisational diversity is closed by new adaptive and contextual forms of quality control. The result is a more socially accountable and reflexive mode of science. Many examples of these phenomena could be drawn from the biomedical and environmental sciences.

Although Mode 1 and Mode 2 are distinct modes of production, they interact with one another. Specialists trained in the disciplinary sciences do enter Mode 2 knowledge production. While some may return to their original disciplinary base others will choose to follow a trail of complex solving problems that are set by a sequence of application contexts. Conversely, some outputs of transdisciplinary knowledge production, particularly new instruments may enter into and fertilise any number of disciplinary sciences. Because of such interactions, there may be a temptation to reduce the new form to more familiar ones, to collapse Mode 2 into Mode 1, and thereby to minimise the significance of the changes outlined above. Though Mode 2 knowledge production interacts with Mode 1 it is different from it. Terms in common usage such as pre-competitive research, strategic research, mission-oriented research, applied research or industrial research and development still carry many of the social preconceptions of the function of disciplinary science; in particular, the idea that disciplinary science provides the inexhaustible well for future applications. The deeply held belief that if the disciplines do not flourish then fundamental insights will be missed, or that foundational theoretical knowledge cannot be produced and sustained outside of disciplinary structures may account for the persistence of the linear model of innovation in policy debates. Yet, it is increasingly the case in computer, materials, biomedical and environmental sciences that theories are developed in the

context of application and that these continue to fertilise lines of intellectual advance that lie outside disciplinary frameworks. In Mode 2 things are done differently and when enough things are done differently one is entitled to say that a new form has emerged.

The reasons why this new mode of production has emerged at the present time are not hard to find. In the first place, Mode 1 has been eminently successful. Scientists long ago discovered that the most effective way to achieve this was through a process of specialisation in the cognitive realm, of professionalisation in the social realm and institutionalisation of the political realm. This pattern has governed the diffusion of science from one area of activity to another and it has tended to treat harshly those who tried to circumvent its controls. The disciplinary structure of knowledge reflects the successful operation of this pattern of cognitive and social control. But over the years the number of graduates grounded in the ethos of research together with some specialist skill have been too large for them all to be absorbed within the disciplinary structure. Some of them have gone into government laboratories, others into industry, while others have established their own laboratories, think-tanks and consultancies. As a consequence, the number of sites where competent research can be carried out has increased. These constitute the intellectual resources for, and social underpinnings of, Mode 2. Seen from another perspective, one might also say that the creation of many new sites is an unintended result of the process of massification of education and research.

The development of rapid transportation, as well as information and communication technologies have created a capability which allows these sites to interact. Mode 2 is critically dependent upon the emerging computer and telecommunication technologies and will favour those who can afford them. The interactions among these sites of knowledge have set the stage for an explosion in the number of interconnections and possible configurations of knowledge and skill. The outcome can be described as a socially distributed knowledge production system. In this system communication increasingly takes place across existing institutional boundaries. The outcome is a web whose nodes are now strung out across the globe and whose connectivity grows daily. Not surprisingly when traditional scientists begin to participate in this they are perceived to weaken disciplinary loyalty and institutional control. But contexts of application are often the sites of challenging intellectual problems and involvement in Mode 2 allows access to these and promises close collaboration with experts from a wide range of backgrounds. For many this can be a very stimulating work environment. Mode 2 shows no particular inclination to become institutionalised in the conventional pattern. The established structure of science can be expected to be concerned about this and about how quality control will be assured in a socially distributed knowledge

production system but it is now a fact of life. Mode 2 is a response to the needs of both science and society. It is irreversible. The problem is how to understand and manage it.

Some Implications of Mode 2

One aim of this book is to draw attention to the existence of a number of attributes associated with the new kind of production of knowledge, and to show that these attributes possess sufficient coherence to be called a new mode of production. We argue that as Mode 1 has become the mode of production characteristic of disciplinary research institutionalised largely in universities, so Mode 2 is characterised by transdisciplinarity and institutionalised in a more heterogeneous and flexible socially distributed system. Having outlined its main features we are now in a position to consider the implications of this development.

The massification of higher education and the appropriation, after the Second World War, by the universities of a distinct research function have produced increasing numbers of people familiar with the methods of research, many of whom are equipped with specialised knowledge and skills of various kinds. Massification is now a strongly entrenched phenomenon, it is international in scope and is unlikely ever to be reversed. On the supply side, the numbers of potential knowledge producers flowing out of higher education is increasing and will continue to do so.

However, this expansion of higher education has an implication that has so far been little examined. Not only are increasingly more people familiar with science and competent in its methods, but also many of these are engaged in activities which have a research dimension. They have brought their knowledge and skills to bear on a wide range of problems in contexts and situations often very remote from the universities where they were originally trained. Scientific and technological knowledge production are now pursued not only in universities but also in industry and government laboratories, in think-tanks, research institutions and consultancies, etc. The expansion of higher education, internationally, has meant that the numbers of potential sites where recognisably competent research is being performed have increased. The implication, not yet fully grasped, is that to the extent that universities continue to produce quality graduates, they undermine their monopoly as knowledge producers. Many graduates have subsequently become competent to pass judgement on university research and belong to organisations which might do the job just as well. Universities are coming to recognise that they are now only one type of player, albeit still a major one, in a vastly expanded knowledge production process.

In parallel with this vast expansion in supply has been the expansion of the demand for specialist knowledge of all kinds. The interaction of

supply and demand for specialist knowledge has many characteristics of a market, but there are some crucial differences. The function of a market is to bring supply and demand into balance and establish the terms of exchange. Traditionally, markets are understood to establish the prices at which the supply and demand of particular commodities will be in equilibrium. A market is a mechanism for allocating resources – labour and capital – to the production of commodities. It works most effectively in cases for which there is already a clearly specified demand and for which the factors of production are available. But markets also have a dynamic component. They can call forth new commodities the demand for which barely exists or, conversely, they can stimulate demand for commodities whose features are as yet unclear. In dynamic markets supply and demand mutually articulate one another.

Knowledge plays a crucial role in many dynamic markets. It is an important source of created comparative advantage for both its producers and users of all kinds and not only in industry. In some of these markets the terms of trade are more complex than may be indicated by comparative levels of costs and prices, and the medium of exchange more subtle than money. For example, in those markets which articulate the supply and demand for knowledge about the environment, there are many different kinds of exchanges among the many participants but the medium is a more complex blend of individual and social values than could be captured by monetary values alone. Because comparative advantage cannot be reduced to economic criteria such markets may be described rather as social than commercial markets but they are markets none the less. Within such markets, the sources of demand are manifold. They come from society in the form of public enquiries of various kinds, from governments in regard to a wide range of issues such as the adverse consequences of high risk technologies, and from a whole spectrum of institutions, interest groups and individuals who need to know more about particular matters. This complex set of actors form hybrid fora which provide stimuli for both the supply and demand of specialised knowledge. Both theoretical and practical knowledge are generated in these fora.

The requirement of industry for knowledge, particularly for the results of scientific and technological research, is widely appreciated. The expansion of demand for a flow of specialist knowledge among firms is perhaps less well understood. Specialist knowledge is often a key factor in determining a firm's comparative advantage. As the pressures of international competition increase firms have tried to meet the challenges presented through the introduction of new technologies. New technology is a necessary but not sufficient condition for successful innovative performance and increasingly, technological innovation depends upon using specialised knowledge to develop technologies in directions dictated by competitive pressures. Specialist knowledge is used partly because it provides a

constantly replenishable source of created comparative advantage and partly because it can be difficult to imitate, particularly by firms whose national culture does not yet support a well articulated science and technology infrastructure. Since, in many sectors these firms represent the spearhead of international competition, specialised knowledge is at a premium but its acquisition is difficult and often too expensive for individual firms to replicate entirely in-house. To meet this exigency firms have become involved in a complex array of collaborative arrangements involving universities, governments and other firms, sometimes from within the same sector. In each case supply and demand are mediated by a market mechanism, but, again, it is not, or need not be, a narrowly commercial one.

In these markets knowledge itself may be sought continuously, but more often than not it is not readily available to be bought or sold, off the shelf, like other commodities. It is increasingly generated in the market nexus itself. In producing specialised knowledge markets operate to configure human and physical resources in a particular context of application. As a consequence of intensifying competition, the number of these contexts is expanding but the contexts are also transient. Markets are dynamic. They set new problems more or less continuously and the sites of knowledge production and their associated networks of communication move on. Knowledge is produced by configuring human capital. However, unlike physical capital, human capital is potentially more malleable. Human resources can be configured again and again to generate new forms of specialised knowledge. The ability to do this lies at the heart of many economies of scope which are currently regarded as crucial to survival in the marketplace.

The core of our thesis is that the parallel expansion in the number of potential knowledge producers on the supply side and the expansion of the requirement of specialist knowledge on the demand side are creating the conditions for the emergence of a new mode of knowledge production. The new mode has implications for all the institutions whether universities, government research establishments, or industrial laboratories that have a stake in the production of knowledge. The emergence of markets for specialised knowledge means that for each set of institutions the game is changing though not necessarily in the same way or at the same speed. There is no imperative for all institutions to adopt the norms and values of the new mode of knowledge production. Some firms and universities are already a long way along the path of change and this is manifested in the types of staff they recruit and in the complex range of collaborative agreements that they enter. However, the institutional goals to be achieved, the rules governing professional development and the social and technical determinants of competence will all need to be modified to the extent that the new mode of production becomes established.

The new mode – Mode 2 – is emerging alongside the traditional disciplinary structure of science and technology – Mode 1. Indeed, it is an outgrowth of it. In order to make clear what is involved in the new mode of production, the attributes of Mode 2 have been contrasted with those of Mode 1. From this analysis it will be clear that Mode 2 is not supplanting but rather is supplementing Mode 1. Mode 2 constitutes a distinct mode with its own set of cognitive and social norms. Some of these contrast sharply with deeply held beliefs about how reliable theoretical and practical knowledge should be generated but they should not for that reason be regarded as either superior or inferior to those operating in Mode 1. They are simply different. To some extent, however, the way in which Mode 2 becomes established in a particular context will be determined by the degree to which Mode 1 institutions wish to adapt themselves to the new situation.

The emergence of a socially distributed knowledge production system means that this type of knowledge is both supplied by and distributed to individuals and groups across the social spectrum. Communications at institutional levels tend to be bypassed because of the need for rapid, flexible responses to problems. Although one may expect variety in the extent that Mode 2 becomes dominant, it is a correlate to the socially distributed knowledge production system which is now emerging. To the extent that institutions become permeable, then Mode 2 can operate. The degree to which current knowledge producing institutions become more permeable will not alter the fundamental fact that knowledge production is becoming more widely distributed; that is, it takes place in many more types of social settings; that it is no longer concentrated in a relatively few institutions, and involves many different types of individuals and organisations in a vast array of different relationships. Such behaviour will simply cause other linkages to become established which in the end may leave them scientifically and technically isolated from some intellectual developments.

Socially distributed knowledge production is tending towards the form of a global web whose numbers of inter-connections are being continuously expanded by the creation of new sites of production. As a consequence, in Mode 2 communications are crucial. At present this is maintained partly through formal collaborative agreements and strategic alliances and partly through informal networks backed up by rapid transportation and electronic communications. But this is only the tip of the iceberg. To function the new mode needs to be supported by the latest that telecommunications and computer technologies have to offer. Mode 2, then, is both a cause and a consumer of innovations which enhance the flow and transformation of information.

It is one of the imperatives of Mode 2 that exploitation of knowledge requires participation in its generation. In socially distributed knowledge production the organisation of that participation becomes the crucial factor. The goals of participation are no longer simply to secure some national advantage, commercial or otherwise. Indeed, the very notion of what constitutes an economic benefit, and for whom, is at the root of many debates not only in environmental science but in biotechnology and the medical sciences as well. For example, the current push towards 'clean' technologies is about more than just economic benefit. It is also about stabilising collapsing ecological systems, the health and well being of populations as well as commercial gain. This is to say that although Mode 2 is exemplified in this book only in relation to knowledge production, it has co-evolutionary effects in other areas, for example in economics, the prevailing division of labour, and the sense of community.

The appearance of Mode 2 is creating new challenges for governments. National institutions need to be de-centred – to be made more permeable – and governments through their policies can promote change in this direction. These policies will be more effective if, concurrently, they become more proactive brokers in a knowledge production game which includes, in addition to the interests and ambitions of other nations, the policies of supranational institutions, such as the European Union (EU). The effectiveness of governments' brokering abilities now underlies the competitiveness of their national innovation systems. This will be reflected both in their ability to participate in knowledge production that may be taking place anywhere in the world but also in their ingenuity in appropriating that knowledge with their innovation system.

Ingenuity is required because sooner or later collaboration must turn into competition. This is in the nature of the wealth creating process as it is presently constituted. Simply to monitor the interface between competition and collaboration would be a difficult enough task. To manage it to national advantage is a challenge that governments will neglect to their cost. As with scientists and technologists, governments, too, need to learn to operate in the context of application, and increasingly this involves supranational institutions. These have political, social and economic dimensions in the case of the EU in Western Europe, but more narrowly economic aims in the cases of the North American Free Trade Agreement (NAFTA) and the General Agreement on Tariffs and Trade (GATT). Key questions are whether supranational institutions can assist in this and how nations ought to position themselves relative to these larger systems.

It is perhaps ironic that it should fall to governments to punch holes in the very institutions that in an earlier day were established to maintain its science and technology capability. But along with many other apparently fixed notions, the purpose and function of these institutions need to be rethought in the light of the emergence of Mode 2. This will reveal the need for a different approach to policy, particularly for the integration of education, science and technology and competition policy into a

comprehensive innovation policy that is sensitive to the fact that knowledge production is socially distributed. In Europe, particularly, national policies that will enhance the potential of national institutions need to be developed in concert with those of the EU. The developing countries, too, need to take stock. For many of them, access will continue to be a problem not only because capability is lacking but also because governments there still model their scientific and technological institutions on assumptions that no longer apply to the kinds of scientific and technological activities on which their aspirations depend.