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Foundations of Technology Development, Innovation and Competitiveness in the Globalised Knowledge Economy

RACHEL PARKER

Abstract *With the growth of high-technology industries and knowledge intensive services, the pursuit of industrial competitiveness has progressed from a broad concern with the processes of industrialisation to a more focused analysis of the factors explaining cross-national variation in the level of participation in knowledge industries. From an examination of cross-national data, the paper develops the proposition that particular elements of the domestic science, technology and industry infrastructure—such as the stock of knowledge and competence in the economy, the capacity for learning and generation of new ideas and the capacity to commercialise new ideas—vary cross-nationally and are related to the level of participation of a nation in knowledge intensive activities. Existing understandings of the role of the state in promoting industrial competitiveness might be expanded to incorporate an analysis of the contribution of the state through the building of competencies in science, technology and industry.*

Keywords:

Introduction

For some time debates dealing with globalisation and the erosion of national influences over economic and social outcomes have been derived from an analysis of the globalisation of trade, production and finance and the erosion of autonomy in areas such as fiscal policy, monetary policy, labour market policy and social policy.[1] When the globalisation debate has incorporated an analysis of technology, it has tended to portray technology as a driving force behind globalisation. Such a perspective suggests that it is advances in information, communications and media technologies that have facilitated new forms of international economic interaction, reduced the cost of global transactions and international trade, and eliminated spatial and time barriers to cross-national economic activity.[2]

In this view, technological progress has facilitated international economic interaction on a scale that is unprecedented in the history of capitalist economies,

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placing constraints on national governments in the areas of welfare policy, taxation policy and labour market policy, as global economic forces, such as financial markets and MNCs, view government policy intervention suspiciously. Technological advances are believed to have empowered MNCs and financial markets through enhanced mobility and fluidity. This is thought to have created an inevitable and uncontrollable bias in the international system towards liberal markets creating pressures for convergence of national policy regimes and the erosion of non-market influences over economic and social outcomes.[3]

This paper departs from debates on the technological foundations of globalisation and the loss of national policy autonomy by analysing the role of technology and innovation, not as driving forces in the process of globalisation, but as potentially important foundations of industrial competitiveness in an era in which technology, knowledge and innovation are of increasing value.

Evidence of the growing importance of technology and innovation in wealthy countries is signalled by several key developments that are broadly associated with the growth of the knowledge economy. First, there has been a shift in the structure of value added and trade amongst OECD countries involving a decline in the share of low and medium-low technology industries and an increase in the share of high technology industries. The share of medium-high and high technology industries in international trade increased from 18 to 25% during the 1990s and their share of domestic value added was 9% amongst the OECD countries by the end of the 1990s. The fastest growing sectors in international trade are pharmaceuticals, radio, TV and communications equipment and computers, all of which are regarded as high technology industries. Second, there has been a growth in knowledge intensive services activities, such that knowledge-based services now account for around 15% of business value added in the OECD countries. Third, the ICT sector constitutes an increasing component of total economic activity amongst the OECD countries with its share of value added increasing from around 8 to 9.5% between 1995 and 1999. The ICT sector therefore accounts for almost 10% of business sector value added in the OECD countries and an increasing component of international trade.[4]

As a consequence of these trends, information and knowledge resources have been recognised as being critical to competitiveness.[5] On this basis, it is possible to expand existing understandings of the institutional foundations of industrial competitiveness, which have tended to focus on the development of engineering and manufacturing competences in traditional industry sectors to incorporate a concern with knowledge activities.[6] With the growth of high-technology industries and knowledge intensive services, debates on competitiveness have progressed from a broad concern with the processes of industrialisation to a more focused analysis of the factors explaining cross-national variation in the level of participation in knowledge industries.[7]

As such, analysis of the implications of globalisation for policy and institutional convergence needs to take into account the critical importance of knowledge creation as the basis of competitiveness. In an environment in which information, technology and knowledge have become critical resources, the institutional and cultural foundations of technology development and innovation constitute a potentially important field of difference at a national and local level.[8]

From an examination of cross-national data, the paper develops the proposition that technology development and innovation are related to national and local competencies. Particular elements of the domestic science, technology and industry infrastructure—such as the stock of knowledge and competence in the economy, the capacity for learning and generation of new ideas and the capacity to commercialise new ideas—vary cross-nationally and are related to the level of participation of a nation in knowledge intensive activities.

The findings have important implications for debates concerning the foundations of industrial competitiveness in the globalised knowledge economy because they are suggestive of an important dimension of cross-national variation in science, technology and industrial competency with implications for comparative economic performance. The final section of the paper suggests that existing understandings of the role of the state in promoting industrial competitiveness, such as that derived from Riain's analysis of the flexible development state in Ireland and Audretsch and Thurik's[9] analysis of the role of the state in the entrepreneurial economy, might be expanded to incorporate an analysis of the contribution of the state through the building of competencies in the science, technology and industry infrastructure.

The Foundations of Technological Development and Innovation in the Knowledge Economy

Debates concerning the foundations of manufacturing success in post-World War II economies have incorporated an analysis of the role of the state in coordinating economic activity. The concept of 'state strength' initially drew attention to the capacity of the state to resist pressure from major interest groups or to impose decisions on major social and economic actors. The degree of centralisation of bureaucratic decision-making and the nature and role of administrative elites were explored as elements of 'state strength'. In relation to industry policy, state strength was associated with an ability to develop and implement industry policies independently of major political interests.[10]

The concept of the developmental state was instead based on the idea of 'state capacity' or the ability of the state to develop and achieve specific industry policy objectives and to mobilise private interests in the pursuit of those objectives.[11] Statist analysis suggested that state–industry relations were critical in explaining the ability of some nations to rapidly adapt to international economic change by conquering new export markets or upgrading technological capabilities. A key characteristic of state capacity was the existence of policy linkages between the bureaucracy and industry, which are able to coordinate the investment decisions of industry. The state provided an 'encompassing organizational complex' that was able to organise industry around long term objectives and socialise the high risk associated with the development and diffusion of new technologies and production processes.[12] To illustrate this argument, research in this tradition has drawn heavily on the experience of East Asian economies, particularly Japan. It is argued that institutions of the state have developed formal and informal links with the private sector that enable them to gather information and coordinate activities across a range of sectors and industries. In addition, the organisation of business has been encompassing rather than fragmented and has been structured through centralised industry associations.[13]

More recent analysis of the role of the state in the knowledge economy has suggested that the basis of state-led competitiveness in knowledge based activities is somewhat different from that associated with the building of competitiveness in medium-technology manufacturing industries which involved the state targeting 'national champions' or key large corporations in important industry sectors. Using Ireland as a case study, Riain builds the concept of the 'flexible development state' to explain relatively recent success in knowledge activities such as ICT.[14] According to Riain, the flexible development state takes on the role of linking local and global technology networks by embedding global business in local and regional economies and by facilitating the integration of local business with global technology networks.

Audretsch and Thurik also distinguish between the role of the state in the post-World War II 'managed economy' and its role in the knowledge economy or as they describe it, the 'entrepreneurial economy'.[15] They identify four characteristics of the role of government in the knowledge economy that can be contrasted to its role in the post-World War II managed economy. First, governments have shifted their emphasis from regulation (through public ownership and anti-trust) to stimulation by creating an environment of knowledge creation through research policies and education policies. Second, governments focus on inputs into the innovation system (such as skills and knowledge) rather than outputs such as favoured firms or industries. Third, there is an increased emphasis on regional and local policies in the knowledge economy rather than national policies given the importance of local learning processes and tacit knowledge. Fourth, there is a public policy emphasis on high-risk venture capital finance (rather than low risk capital), which is essential to the commercialisation of new ideas.

These recent contributions have drawn attention to the importance of post-Fordist organisational structures and informal and decentralised learning processes in seeking to reconceptualise the role of the state in industrial competitiveness in the globalised learning economy. It is possible to build on this trend in the literature by exploring the processes of technology development and innovation in the knowledge economy. Understandings of the nature and processes of innovation and technology development provide important insights that can be used to further develop conceptualisations of the role of the state in the globalised learning economy.

In the 1950s and 1960s, formal processes of technology development were the focus of studies of scientific and technological excellence because it was assumed that scientific research acted as a 'push' factor for innovation and that research and development, undertaken either by governments or research and development departments within firms, were the drivers of innovation and new technology. Basic research activity was regarded as the basis of radical innovations in the form of new products and new technological trajectories.[16] As such, science and technology policy had a definite R&D focus.

From the 1970s there has been a broadening of the analysis of innovation from a focus on new products and the application of new technologies to encompass a greater concern with less formal processes of innovation involving product improvements and modifications, organisational processes and forms of work organisation. The National Systems of Innovation (NSI), Technological Systems (TS) and Regional Innovation Systems (RIS) approaches have incorporated this broad view of innovation and provide a framework for understanding national and local influences on less formal processes of innovation and technology development. From this body of literature it is possible to gain an understanding of national and local competencies which are important for innovation and which might provide a point of focus for state initiatives to promote industrial competitiveness that go beyond the earlier focus on R&D.

In the NSI, TS and RIS approaches, innovation is defined broadly to include the development and uptake of technology, the introduction of new products or processes, the introduction of different forms of work organisation or management structures and approaches and the utilisation of new market opportunities. All of these various forms of innovation appear to be important for growth, productivity and competitiveness in the knowledge economy.[17] This literature provides further support for the importance of national and local influences on informal processes of knowledge development and diffusion, suggesting that the national technology or innovation system is a critical domain for public policy intervention in the knowledge economy.

The NSI and TS approaches provide a useful conceptual framework for understanding technology development and uptake, or innovation, within particular national contexts. In seeking to develop an understanding of innovation within a particular national context, the NSI and TS approaches have explored a range of institutions closely linked to the innovative process. For example, Carlsson and Stankiewicz have referred to the institutions that constitute the technological system as the 'set of institutional arrangements (both regimes and organizations), which directly or indirectly, support, stimulate and regulate the process of innovation and diffusion of technology'.[18]

This literature has shown that institutional arrangements which have an important impact on innovation include those associated with the state, the education system, research infrastructure, the industrial relations and training system, financial markets, the system of labour relations and the organisation of business itself, both within firms (intra-organisational) and between firms (inter-organisational). The cultural context, including codes of behaviour and values such as trust, attitudes to authority, and conceptions of fairness, also impact on the innovative behaviour of economic actors because they impose constraints and provide opportunities for owners, managers, workers and regulators.[19] A nation's values and norms, state institutions, industrial relations system, finance sector, industry associations, trade unions and business organisations constitute a *system* within which innovation takes place.

Further, research on regional innovation systems (RIS) has shown that spatial proximity is important in local processes of learning that contribute to industry innovation. The innovative activities of a firm are affected by its spatial proximity to knowledge sources that are external to the firm including universities, public research institutions and other firms, especially knowledge intensive firms. The importance of spatial proximity arises from learning by interacting which results in the transfer of local knowledge including tacit knowledge resulting from learning by doing and using. Regional innovation occurs within a system of learning amongst a variety of actors including firms, local government authorities, public research institutions and education and training bodies and may depend on the support of national governments particularly in regions that are economically poor.[20]

These traditions have contributed to an understanding of national and local influences on informal processes of technology development. The NSI, TS and RIS approaches provide a conceptual basis for analysing the way in which national and local factors might impact on innovation and the commercialisation of new ideas in modern economies and in particular the less formal dimensions of innovation. From this literature it is possible to identify several national competencies which are linked to technology development and innovation and which might help to explain the level of participation of nations in knowledge activities. It is these national competencies which might provide the focal point for expanded state involvement in the promotion of innovation and competitiveness. The following section of the paper utilises the concepts associated with the NSI, TS and RIS approaches to explore the relationship between key national competencies and the level of participation in the knowledge economy in 15 OECD countries.

The Science, Technology and Industry Infrastructure in 15 OECD Countries

The notion of the science technology and industry infrastructure (STII) is designed to describe an important component of the environmental context of technology development and innovation in the knowledge economy. As such, the idea of the STII draws on several key bodies of research on national systems of innovation,[21] technological systems,[22] national innovative capacity[23] and competence blocs.[24] These literatures highlight the competencies that provide the basis for new knowledge generation and diffusion as well as environmental conditions which impact on the capacity to commercialise new knowledge. Drawing on these bodies of literature it is possible to develop the notion of the STII to describe those aspects of the environmental context of business that would be expected to be of critical importance to innovation and technology development. The STII includes but goes beyond the traditional tangible infrastructure of traditional industries to incorporate soft or intangible infrastructure associated with knowledge generation and diffusion.[25]

The following discussion reports evidence on differences in national competencies linked to innovation and technology development in 15 OECD countries. The discussion reports evidence of the relationship between these national competencies and the extent of participation in knowledge intensive activities.

The conceptual basis of the following empirical analysis is the science, technology and industry infrastructure (STII) which compromises the infrastructure or competencies of nations associated with innovation and technology development as explained in the literature on TS, NSI, RIS and competence blocs. The STII is described in terms of three elements—the existing stock of knowledge and competence of the workforce, the potential for generation and diffusion of new knowledge, and the capacity for commercialisation of new ideas.

The Existing Stock of Knowledge of the Workforce

Research on NSI, TS and RIS has explained that the capacity of a nation to participate in knowledge intensive activities is related to the presence of sufficient stock of knowledge and competence amongst the labour force such that the labour force is able to contribute to innovation in critical knowledge intensive activities.[26] An important part of the STII concerns the structure of the skill base arising from the orientation of the education and training system and, in particular, its development of competencies in industry and technology, affecting the availability of highly skilled workers to contribute to knowledge intensive activities. A well skilled population, particularly in engineering and ICT, may be regarded as an important source of entrepreneurs in knowledge intensive sectors and therefore of relevance to the establishment of new firms in new industry sectors.[27]

Table 1 reports three key measures of the stock of knowledge and competence of the workforce in 15 OECD countries. The first is the proportion of the population that has attained at least upper secondary education (EDUC)—an indication of the overall skills of the labour force, which would be expected to be important for participation in knowledge intensive economic activities. Second, the proportion of tertiary graduates in engineering, manufacturing and construction is reported (EDEMC). This measure would be expected to be of particular importance for participation in knowledge intensive industries. Finally, the proportion of graduates in computing is relevant to ICT services and is reported in column 4 of Table 1 (EDCOM).

These figures reveal a large variation in the stock of knowledge and competence in the wealthy countries. The proportion of the population to have reached upper secondary is 65% or below in countries such as France, Italy, UK, Australia and Ireland and is 80% or more in Austria, Denmark, Canada, Sweden, Japan, Germany and the USA. Over 20% of tertiary graduates occupy fields of relevance to knowledge industries (such as engineering and manufacturing) in Finland, Sweden, Japan, with Germany falling not far behind. The figure is less than half that in Australia, Denmark, Canada, Ireland, UK and USA. A different pattern exists for tertiary education in ICT, with Ireland and the UK as the leaders and Belgium, the Netherlands, Denmark and Italy falling behind.

The Potential for Learning and the Generation of Knowledge

The potential for learning and the generation of new knowledge—or the capacity to develop new ideas—is critical in knowledge intensive sectors in which knowledge is the basis of competitiveness. Research and development has been regarded as critical for the generation of new knowledge. However, innovation studies have shown that innovation is a process of interactive learning between a firm and its environment, involving feedback mechanisms or loops, representing the complex interactions between a variety of institutions in the system as part of a continuous process involving incremental change, error and modification.[28] Knowledge activities do not follow a linear trajectory, moving in a straight path from basic research to applied research to commercial application.[29] As such, while R&D provides some indication of the potential for the generation of new ideas, interactions between firms and other institutions is a key element of the learning process associated with knowledge intensive activities.

In analysing the potential for learning and generation of knowledge in knowledge intensive industries, it is important to include a measure of formal R&D and also a measure of less formal interactions within society which can lead to knowledge sharing. The measure of trust available through the World Values Survey constitutes a proxy for social interactions that provides some indication of the likelihood of firms interacting for the purpose of sharing information and therefore contributing to the generation of new knowledge.[30]

These measures are reported in Table 1 for the 15 OECD countries. Large variation exists in the level of R&D expenditure which constitutes 3% or more of GDP in Finland, Sweden and Japan and around half that in Australia and Canada and even less in Italy. Variation also exists in the OECD measure of trust from 50% or more of the population indicating that they trust their fellow citizens in Denmark, the Netherlands, Canada and Sweden to less than 35% in the UK, Belgium, Austria and France.

Table 1. The science, technology and industry infrastructure and knowledge economy in 15 OECD countries

	EDUC	EDEMC	EDCOM	TOTALR&D	TRUST	VENCAP	KNOWIND	ICTSER	KNOWEC
Australia	65.00	7.90	4.60	1.50	39.90	0.09	5.70	9.30	15.00
Italy	52.00	16.00	0.90	1.04	35.30	0.08	7.30	8.41	15.71
Austria	80.00	17.30	2.80	1.80	31.80	0.02	7.30	8.62	15.92
Denmark	85.00	8.90	1.80	2.00	57.70	0.03	6.40	9.70	16.10
France	40.00	11.20	2.70	2.20	22.80	0.12	7.40	9.10	16.50
Canada	86.00	8.20	2.80	1.66	52.40	0.18	7.30	9.62	16.92
Finland	79.00	24.00	2.20	3.19	47.60	0.11	10.00	11.94	21.94
Sweden	83.00	20.50	3.10	3.80	59.70	0.22	10.00	12.60	22.60
Ireland	65.00	9.30	8.40	1.40	47.40	0.08	16.40	14.69	31.09
Japan	85.00	21.30	–	3.00	46.00	0.02	10.70	7.40	18.10
Germany	86.00	19.00	2.80	2.40	41.80	0.08	11.70	6.70	18.40
Netherlands	72.00	10.40	1.50	2.00	55.80	0.26	6.20	11.50	17.70
UK	61.00	9.90	4.20	1.90	31.00	0.50	8.10	10.60	18.70
USA	91.00	6.50	2.80	2.60	35.60	0.28	8.50	10.60	19.10
Belgium	68.00	12.50	1.00	1.80	33.20	0.12	8.30	12.31	20.61
Mean 15 countries	73.20	13.53	2.97	2.15	42.53	0.15	8.75	10.21	18.96

Source and definitions: see data appendix.

Capacity for Commercialisation of New Ideas

In order to bring new ideas to the market it is necessary to have venture capital support, particularly in relation to new industries that depend on new firm start-ups, where the risks and potential rewards are both high. This includes industries such as ICT services. As such, venture capital markets are an important component of the STII. Eliasson has made reference to the importance of 'competent' venture capitalists who have sufficient expertise to understand new business proposals.[31] Table 1 reports the level of venture capital activity in 15 OECD countries which ranges from 0.02 of GDP in Austria and Japan to over 0.25 in the USA, the UK and the Netherlands.

The Relationship between the STII and Participation in the Knowledge Economy

The above analysis has revealed cross-national variation in the STII across the 15 OECD countries. The following discussion reports evidence on the relationship between the STII and participation in the knowledge economy in 15 OECD countries. Two measures of participation in the knowledge economy are reported in Table 1. The first concerns the share of knowledge intensive industries (medium-high and high technology industries) in business value added. The second concerns the share of ICT services in business services value added. These measures are intended to capture the growing importance of knowledge intensive industries and knowledge intensive services in modern economies.

Cluster analysis was used to group countries on the basis of their scores on the two measures of participation in the knowledge economy. Five distinct clusters were identified. Within each cluster, countries had similar scores on the two measures of participation in the knowledge economy and their scores were different from countries in the other clusters. Cluster analysis shows that it is possible to identify countries whose participation in knowledge intensive activities is similar to other countries in their cluster but different from countries in other clusters. In order to explore the relationship between the STII and patterns of performance in knowledge intensive activities, Figures 1–5 map the Z scores (standardised means) for the five clusters on each of the six elements of the STII. From these figures, it is possible to compare the means for the cluster against the mean for the group of 15 countries.[32]

Cluster 1 consists of Italy, Austria, France, Canada, Australia, Denmark and the Netherlands. For all of these countries, the total level of participation in knowledge activities, as defined by the sum of KNOWIND and ICTSER, is well below the mean for the 15 countries as a whole. Except for the Netherlands, all of these countries perform below the mean for the 15 countries in both their level of participation in knowledge industries as well as ICT services.[33] As such, this cluster might be regarded as a group of countries that are poor performers in the knowledge economy. This group can be contrasted with Cluster 2 which consists of Finland and Sweden. Both of these countries have a level of participation in both KNOWIND and ICTSER that exceeds that for the group of 15 countries as a whole. Both Finland and Sweden might be regarded as good performers in terms of their level of participation in the knowledge economy. Ireland makes up Cluster 5 and stands alone from the other countries. Ireland's performance in both knowledge industries and ICT services is so much higher than the mean for the 15 countries that it constitutes a separate cluster that cannot be regarded as similar to any of the other countries.

The USA, the UK and Belgium constitute Cluster 3. The overall level of participation in knowledge intensive activities in the UK and the USA is very close to the mean for the 15 countries. Belgium is slightly above the 15-country mean. The distinguishing feature of this cluster is that the performance of countries in this cluster in ICT services is above the mean for the 15 countries while their performance in knowledge industries is below the mean. This may indicate a relative strength in knowledge intensive services rather than knowledge intensive industries. Cluster 3 can be contrasted with Cluster 4, which consists of Japan and Germany. These two countries have the reverse pattern of performance to the Cluster 3 countries. Both Japan and Germany have a strength in knowledge intensive industries in which their performance is well above the mean, while their performance in ICT services is clearly below the mean for the 15 countries.

Figure 1 shows that for Cluster 1, which consisted of seven countries that might be described as poor performers in the knowledge economy, the STII is underdeveloped relative to the mean. The stock of knowledge and competence in the economy might be described as low, given that the proportion of the population that has reached upper secondary education is below the mean, as is the orientation towards tertiary education in engineering, manufacturing and computing. Further, the capacity to develop new ideas might be regarded as low given the low level of investment in R&D and the fairly weak level of trust, which might discourage information sharing and collaboration amongst business organisations and other knowledge institutions. Finally, the capacity to commercialise ideas might be described as weak for this cluster given low levels of venture capital funding. It would therefore seem that this cluster represents a group of countries that have a weak STII and a poor level of participation in the knowledge economy.

A strong contrast can be drawn between this group and Cluster 2 which consists of two countries whose participation in the knowledge economy is relatively high. For Cluster 2, performance across most dimensions of the STII is above the mean. The stock of knowledge and competence might be regarded as high given the high proportion of the population to have reached secondary education and the strong orientation towards training in engineering and manufacturing. The orientation towards tertiary education in computing for Finland is below the mean for 15 countries, although this might be a consequence of very high levels of training in engineering, which also feeds into the ICT sector particularly with its strong association with Ericsson and Nokia in these two countries. The capacity to develop new ideas is high for this cluster, given both high levels of trust, which is likely to contribute to informal interactions contributing to knowledge generation and high levels of investment in R&D, which is associated with more formal processes of knowledge development. The final dimension of the STII, the capacity to commercialise ideas, is also relatively strong in this cluster, mainly because of the well-developed venture capital market in Sweden, which is strongly supported by public venture capital funds such as industrifonden.

The other clusters represent more complex patterns of performance across the dimensions of the STII. Cluster 3 consists of countries with a relatively strong performance in the services dimension of the knowledge sector and a weaker performance in knowledge industries. The STII explains this pattern of performance to some extent. On most dimensions of the STII, this group performs below the mean when compared to the group of 15 as a whole, although the group is not so far below the mean as is the case for Cluster 1. This would seem to be consistent with a relatively low level of performance in knowledge activities. The stronger orientation of the group to ICT services might be explained by the relatively strong venture capital market, which has been important in the ICT sector, given its early stage of development. The level of education in computing is closer to the mean than for Cluster 1. In contrast, Cluster 4 has a weak performance in the ICT sector and relatively small venture capital market. In most other areas of the STII, Cluster 4 performs above the mean, which is consistent with good performance in knowledge industries.

Ireland stands out separately from the other four clusters. Its performance across most areas of the STII is close to but mostly below the mean. The clear exception concerns the orientation of its tertiary education sector towards computing which is well above the mean for the other 15 countries and provides a potential explanation for Ireland's performance in ICT. This might indicate that Ireland's performance in knowledge industries is linked to a strong skills base in ICT.

The above analysis has shown that for each of the five clusters of distinctive performance in knowledge sectors, there appears to be a relationship between characteristics of the STII and the level and nature of participation in knowledge activities. The clearest pattern exists for Clusters 1 and 2, which represent the strong and weak performers in knowledge sectors. The analysis is suggestive of a link between the STII and patterns of performance in knowledge sectors in that countries with a strong capacity to develop and commercialise new ideas and a well developed stock of knowledge and competence in the economy appear to have a higher level of participation in the knowledge economy.

The Role of the State in Building Science, Technology and Industry Competencies in the Knowledge Economy

The national systems of innovation, technology systems, regional innovation systems and competence bloc literature have revealed the importance of national and local competencies in technology development, informal processes of interactive learning and consequently industry competitiveness. The paper has explored differences amongst 15 OECD economies in the science, technology and industry infrastructure—the level of skills and competence of the labour force, the capacity for learning and generation of new knowledge and the capacity for commercialisation. Available data indicate that countries fall into distinct clusters based on levels of participation in knowledge activities. Further, an analysis of the STII of each of the clusters is suggestive of a relationship between the level of participation in the knowledge economy on the one hand and the stock of knowledge and competence in the economy and the capacity to develop and commercialise new ideas on the other. Across the clusters, these characteristics of the knowledge infrastructure appear to have some relationship to the extent to which the nation participates in knowledge intensive activities.

The findings provide evidence of the need to widen the debate on globalisation and the erosion of national influences over domestic economic outcomes by examining the role of national competencies in influencing technology development and innovation and therefore industrial competitiveness. Policies influencing the stock of knowledge and the capacity for learning and commercialisation of knowledge at a national and local level seem to be related to the level of participation in knowledge activities and would therefore seem to be associated with industrial competitiveness in the knowledge economy. This reveals a potentially important area of governance in an era where global economic change may have impacted on the capacity of governments in other areas of economic policy making.

Governments may be able to influence levels of participation in knowledge industries by influencing the stock of knowledge and competence in the economy through education policies that improve the overall educational attainment of the workforce and which target sectors such as engineering and computing which seems to have been particularly important in Finland, Sweden and Ireland. Further, public policy influences over the formal development of new ideas, through funding of the science base and research institutions and the provision of incentives for private R&D, provides a mechanism for influencing the capacity to develop new ideas as do policies which encourage less formal processes of knowledge development including networks and public–private partnerships. Finally, the state may influence the capacity to commercialise new ideas by establishing public sources of venture capital which compensate for weaknesses in the existing private stock.

This provides a further dimension to existing knowledge on the role of the state in promoting industrial competitiveness in the globalised knowledge economy, such as that derived from the literature on the flexible developmental state in Ireland[34] and the role of the state in the entrepreneurial economy.[35] This literature has contributed important insights into the processes by which the state contributes to industrial transformation. Riain's conceptualisation of the flexible development state has helped to explain the relative success of Ireland in ICT in terms of the role of the state in linking the global and the local by facilitating the integration of local firms in global technology networks and by embedding global firms in local technology networks. Audretsch and Thurik's discussion of the state and the entrepreneurial economy has highlighted the importance of research and education policies in influencing the supply of skills and knowledge in the economy and the importance of regional and local policy engagement.

This paper has suggested that a further dimension of the role of the state in the globalised knowledge economy is that of building competence through the development of the science, technology and industry infrastructure. The above discussion has highlighted national scientific and industrial competences which would seem to provide one component of an explanation for comparative performance in the knowledge economy.

Notes and References

1. For example, Geoffrey Garrett identifies the limits of convergence in major areas of state policy in 'Global markets and national politics: collision course or virtuous circle', *International Organization*, 52, 4, 1998, pp. 787–812. The constraints on fiscal and monetary capacity and the continuing possibilities in the field of social and labour market policy are explored in Geoffrey Garrett and Peter Lange, 'Political responses to interdependence: what's "left" for the Left?', *International Organisation*, 45, 4, 1991, pp. 539–64.
2. See M. Baily, 'Innovation in the new economy', *OECD Observer*, 221–2, Summer 2000, pp. 98–100; P. Dicken, *Global Shift: The Internationalization of Economic Activity*, Paul Chapman, London, 1992, pp. 103–10; P. McMahon, 'Technology and globalisation: an overview', *Prometheus*, 19, 3, 2001, pp. 211–22.
3. The case for the limits of national influence over economic outcomes has most strongly been made in relation to the effects of the globalisation of finance. See P. G. Cerny, 'International finance and the erosion of state capacity', in P. G. Cerny (ed.), *Globalization and Public Policy*, Edward Elgar, Cheltenham, 1996; Jeffry A. Frieden, 'Invested interests: the politics of national

economic policies in a world of global finance', *International Organization*, 45, 4, 1991, pp. 425–51; J. B. Goodman and L. W. Pauly, 'The obsolescence of capital controls? Economic management in the age of global markets', *World Politics*, 46, 1993, pp. 50–82. On the loss of national policy autonomy see J. W. Moses, 'Abdication from national policy autonomy: what's left to leave?', *Politics and Society*, 22, 2, 1994, pp. 125–48; and C. M. Webb, 'International economic structures, government interests and international co-ordination of macro-economic adjustment policies', *International Organization*, 45, 3, 1991, pp. 309–42.

4. The data in this paragraph are taken from OECD, *OECD Information Technology Outlook: ICTs and the Information Economy*, OECD, Paris, 2002a, pp. 30–3; OECD, *Science, Technology and Industry Scoreboard: Towards a Knowledge Based Economy*, OECD, Paris, 2001, pp. 12–3; OECD, *OECD Science, Technology and Industry Outlook 2002*, OECD, Paris, 2002b, p. 286.
5. This is a point made in the innovation systems literature. For an early statement of this principle see B. Lundvall, 'Introduction', in B. Lundvall (ed.), *National Systems of Innovation: Towards a Theory of Interactive Learning,* Pinter, London, 1992.
6. See Chalmers Johnson, *MITI and the Japanese Miracle: The Growth of Industrial Policy 1925–1975*, Stanford University Press, Stanford, 1982 as a classic example of this work.
7. Gunnar Eliasson, 'Industrial policy, competence blocs and the role of science in economic development', *Journal of Evolutionary Economics*, 10, 2000, pp. 217–41. Jeffrey Furman, Michael E. Porter and Scott Stern, 'The determinants of national innovative capacity', *Research Policy*, 31, 2002, pp. 899–933. Seán Ó Riain, 'The flexible developmental state: globalization, information technology, and the "Celtic Tiger"', *Politics and Society*, 28, 2, 2000, pp. 157–93.
8. By showing that a significant proportion of formal technology development activities are national/local rather than global, Archibugi and Michie make a case for the continuing importance of national innovation systems. See D. Archibugi and J. Michie, 'Technological globalisation or national systems of innovation?', *Futures*, 29, 2, 1997, pp. 121–37.
9. Riain, *op. cit.*; David Audretsch and Roy Thurik, 'Capitalism and democracy in the 21st century: from the managed to the entrepreneurial economy', *Journal of Evolutionary Economics*, 10, 1, 2000, pp.17–34.
10. See for example, M. M. Atkinson and W. D. Coleman, *The State, Business and Industrial Change in Canada*, Toronto University Press, Toronto, 1989; and P. Evans, D. Rueschemeyer and T. Skocpol (eds), *Bringing the State Back In*, Cambridge University Press, Cambridge, 1985.
11. See P. Evans, *Embedded Autonomy*, Princeton University Press, Princeton, NJ, 1995; and L. Weiss, *The Myth of the Powerless State: Governing the Economy in a Global Era*, Polity Press, Cambridge, 1998.
12. *Ibid*, p. 6.
13. *Ibid*, pp. 55, 60.
14. Riain, *op. cit.*
15. Audretsch and Thurik, *op. cit.*
16. Christopher Freeman, 'The national system of innovation in historical perspective', *Cambridge Journal of Economics*, 19, 1995, pp. 5–24, 11.
17. For a recent discussion of the various forms of innovation and their contribution to employment and growth, see C. Edquist, L. Hommen and M. McKelvey, *Innovation and Employment: Process versus Product Innovation*, Edward Elgar, Cheltenham, 2001.
18. B. Carlsson and R. Stankiewicz, 'On the nature, function and composition of technological systems', in B. Carlsson (ed.), *Technological Systems and Economic Performance: The Case of Factory Automation*, Kluwer, Dordrecht, 1995, p. 45.
19. For a discussion of the relevance of these factors in explaining cross-national variation in forms of economic organisation, see P. H. Kristensen, 'Variations in the nature of the firm in Europe', in R. Whitley and P. H. Kristensen (eds), *The Changing European Firm: Limits to Convergence*, Routledge, London, 1996.
20. For a discussion of local processes of learning in regional innovation systems see B. Asheim, 'Industrial districts as learning regions: a condition for prosperity?', *European Planning Studies*, 4, 4, 1997, pp. 379–400; K. Morgan, 'The learning region: institutions, innovation and regional renewal', *Regional Studies*, 31, 1997, pp. 491–503; and B. Asheim and E. Clark,

'Creativity and cost in urban and regional development in the new economy', *European Planning Studies*, 9, 7, 2001, pp. 805–11.
21. For the early development of this approach see Lundvall, *op. cit.*; and R. Nelson (ed.), *National Innovation Systems: A Comparative Analysis*, Oxford University Press, Oxford, 1993.
22. Carlsson and Stankiewicz, *op. cit.*
23. Furman *et al.*, *op. cit.*
24. Eliasson, *op. cit.*
25. For a discussion of the importance of intangible and soft infrastructure in the knowledge economy, see D. Rooney and T. Mandeville, 'The knowing nation: a framework for public policy in a post-industrial knowledge economy', *Prometheus*, 16, 4, 1998, pp. 453–67; and G. MacLeod, 'New regionalism reconsidered: globalization and the remaking of political economic space', *International Journal of Urban and Regional Research*, 25, 4, 2001, pp. 804–29.
26. Patel and Pavitt, 1991.
27. Storey and Tether draw attention to the supply of PhDs as a stimulant to new firm start ups in high technology fields. See D. Storey and B. Tether, 'Public policy measures to support new technology-based firms in the European union', *Research Policy*, 26, 1998, pp. 1037–57.
28. C. Edquist, 'Systems of innovation approaches-their emergence and characteristics', in C. Edquist (ed.), *Systems of Innovation: Technologies, Institutions and Organisations*, Pinter, London, 1997, pp. 1–2.
29. Lundvall, *op. cit.*; Freeman, *op. cit.*
30. The World Values Survey provides a basis for cross-national comparison of trust. On the relationship between trust and learning, see B. Uzzi, 'The sources and consequences of embeddedness for the economic performance of organizations: the network effect', *American Sociological Review*, 61, 4, 1996, pp. 674–98; and B. Uzzi, 'Social structure and competition in inter-firm networks: the paradox of embeddedness', *Administrative Science Quarterly*, 42, 1, 1997, pp. 35–67.
31. Eliasson, *op. cit.*
32. Cluster analysis is a statistical procedure used to identify groups of cases (in this case, countries), which have similar characteristics (in this case, similar levels of participation in knowledge intensive activities). *Z* scores are the number of standard deviations from the mean.
33. The Netherlands has a below mean level of participation in knowledge industries (KNOW-IND) but its level of participation in ICT services is above the mean for the 15 countries. While the Netherlands clustered towards this group, its membership of the group was weaker than for the other countries.
34. Riain, *op. cit.*
35. Audretsch and Thurik, *op. cit.*

Data Appendix

EDUC: Proportion of population whose highest educational attainment is at least upper secondary (excluding ISCED 3C), 2001. Source: OECD, 2002b, *op. cit.*, p. 54.

EDSMC: Proportion of Tertiary Type A graduates in engineering, manufacturing and construction, 2000. Tertiary Type A Education (ISCED 5A) 'are largely theory based and are designed to provide sufficient qualifications for entry to advanced research programmes and professions with high skill requirements, such as medicine, dentistry of architecture'. For details see EUROSTAT, *Fields of Education and Training-Manual*, 1999; OECD, 2002b, *op. cit.*, p. 366. Source: OECD, 2002a, *op. cit.*, p. 61.

EDCOM: Proportion of Tertiary Type A graduates in computing, 2000. Source: OECD, 2002a, *op. cit.*, p. 61.

TOTALR&D: Gross expenditure on R&D as percentage of GDP, 1999 or nearest year. Source: OECD, 2001, *op. cit.*, p. 147.

TRUST: Percentage of survey respondents saying that most people can be trusted, 1995–96 (for some countries, data is for 1990–91). World Values Survey reported in OECD, 2001, *op. cit.*, p. 44.

VENCAP: Percentage of total private equity/venture capital investment in GDP, 1995–99. (It does not measure venture capital funds raised.) Private equity is a broader definition than venture capital as it tends to include management buyouts and buy-ins. For measurement problems and limitations on comparability see Baygan and Freudenberg, 2000, pp. 11–3 at p. 19.

KNOWIND: Knowledge industries. Share of value added in medium-high and high technology manufacturing in total value added, 1998 or nearest year. Source: OECD, 2001, *op. cit.*, p. 203.

ICTSER: Share of ICT services in business services value added. Source: OECD estimates, based on national sources; STAN and National Accounts databases, September 2002.

KNOWEC: Sum of KNOWIND and ICTSER.

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	italic	underline	(ital)
	capital letters	underline three times	(caps)
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	bold type	wavy underline	(bold)
	lower case letters	encircle	(l.c.)
	Greek letters	encircle	(gk) adding Greek letter
Delete and close up		copy	
Reduce space		in / copy	less #
Close up space		in copy	
Insert space		incopy	#
Make space in line equal			eq #
Insert space between lines			
Reduce space between lines			
New paragraph		[	(para)
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