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TECHNOLOGICAL GLOBALISATION OR NATIONAL SYSTEMS OF INNOVATION?

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Technological innovation is said to be breaking down borders. The internet, the explosion of globalised financial markets, the increased foreign direct investment by transnational corporations—all are portrayed as creating a global market in which the nation state is little more than an anachronism. And yet some economies have been more innovative and dynamic than others, and there seems no reason to believe that these differences in national economic performance will become a thing of the past. On the contrary, with a global market, any competitive advantage will bring larger rewards. So government action to enhance firms' competitive advantage becomes more important, not less. It is within this context that technological globalisation is analysed in this paper. The question is whether such globalisation spells the end of the nation state. The answer is no. © 1997 Elsevier Science Ltd

Knowledge and technological innovation play a crucial role in economic activities. While this has long been recognised by managers, scientists and engineers, it is only really over the past decade or so that economists have devoted much effort to studying the way in which knowledge actually leads to the generation and diffusion of technological innovation. This attention has, however, produced a vast literature which has begun to shed some light into the 'black box' of the relationship between technology and the productive process (see in particular Rosenberg).[1] The initial hypotheses in a handful of pioneering works during the 1950s and 1960s on the economic determinants and impact of inno-

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vation have since been corroborated by a substantial amount of theoretical and empirical research.[2]

The most fruitful lesson gained by recent research is that technological change should be explored within the social fabric in which the innovative activities are actually developed and used. Innovation is far more than just a series of isolated events shaped by enlightened inventors, forward looking entrepreneurs or dynamic corporations. Certainly, individuals and firms play a crucial role in the development of specific innovations, but the process which nurtures and disseminates technological change involves a complex web of interactions among a range of different subjects and institutions.[3]

To map these interactions, however, is not easy. Innovation-related information flows are of a multifarious nature:

- They take place through both market and non-market transactions. A substantial amount of technology and knowledge transfer takes place regardless of any economic incentives. Individuals imitate and learn; and know-how is often exchanged informally and voluntarily.[4]
- Such flows can take the form of either tangible or intangible assets. Firms use a variety of sources to innovate: a piece of machinery and a scientific paper may both be important sources of innovation.[5]
- They involve not only businesses but also public institutions. Universities, research centres and other government agencies play a crucial role in fostering technological advance, as do profit-seeking business firms.[6]

These various aspects of the process are unlikely to be 'captured' in their entirety simply by looking at standard economic variables such as prices and quantitites alone. To understand technological change it is crucial to identify the economic, social, political and geographical context in which innovation is generated and disseminated. This space may be local, national or global. Or, more likely, it will involve a complex and evolving integration at different levels of local, national and gobal factors.

The relative importance of national and global forces has been the subject of a vast literature. Some authors have claimed that the current process of globalisation is eroding the significance of nations as meaningful subjects of technological change.[7] Others, on the contrary, have argued that the significance of globalisation has been overemphasised since the bulk of firms' innovative activities are still carried out in their home countries.[8]

The thesis which might be dubbed 'techno-nationalism' is not necessarily contradicted by what might at first sight appear to be the alternative thesis, of 'techno-globalism'. The two concepts rather describe two strictly interrelated aspects of contemporary technological change. Certainly, a globalised economy is transforming the landscape for the generation and diffusion of innovation, but this does not appear to decrease the importance of national characteristics nor, even less, of national institutions and their policies. On the contrary, by magnifying the potential costs and benefits which will result from any one country's competitive advantage or disadvantage—as a growing proportion of the home market risks being lost to imports, while a growing proportion of domestic output may be dependent on winning export orders—globalisation will increase the impact that national policy will have on domestic living standards.

Before taking this discussion further, however, some consideration is required of the two key concepts of national systems of innovation on the one hand, and the globalisation

of technology on the other—and also of the main actors (broadly, private firms and public institutions) through which these systems and trends evolve.

Concepts and actors

National systems of innovation

The importance of nation-specific factors in developing technological innovation has been boldly affirmed since the mid 1980s. Chris Freeman introduced the concept of 'National systems of innovation' (NSI) to describe and interpret the performance of the economically most successful country of the post-war period, Japan.[9] Over the subsequent years this concept has experienced a remarkable diffusion and has been applied to several countries and different areas.[10] As Nelson and Rosenberg noted:

> There clearly is a new spirit of what might be called 'technonationalism' in the air, combining a strong belief that the technological capabilities of a nation's firms are a key source of their competitive process, with a belief that these capabilities are in a sense national, and can be built by national action.[11]

Studies in this field were pioneered by two research teams. The first team, led by Bengt-Åke Lundvall at the Aalborg University Centre, investigated the analytical content of the notion of National Systems of Innovation by looking at the role played by users, the public sector, and financial institutions.[12] The second team, coordinated by Richard Nelson, assembled a number of case-studies to describe the main features of the innovative systems of high, medium and low income countries.[13] More recently, the OECD has taken up the idea of national systems of innovation and is making an attempt to operationalise it through the collection and analysis of indicators. In particular, their analysis is focused on the financial dimension, the interconnections among the various institutions and the distribution of knowledge across national agents.

Although the concept of national systems of innovation is defined and applied differently,[14] the various authors share the view that nation-specific factors play a crucial role in shaping technological change. Some of these factors are institutional, such as education, public support to industrial innovation, and defense-related technology schemes. Others are rooted in history, and concern the culture, size, language and vocation of a nation. Crucial to the definition of a national system is how the different parts, such as universities, research centres, business firms and so on interact between each other.

The globalisation of technology

New technologies have always played a crucial role in the processes of economic and social globalisation. Aeroplanes, computers and satellite-based communications make possible an ever-expanding degree of information exchange, commodity trade and individual contact across the globe. Indeed, it is often argued that the current globalisation would be impossible without such technologies.[15] Communication and transport technologies, however, might be better described not so much as reflecting the globalisation of technology as representing *the technologies of globalisation* since they service the increasingly global operation of cultural, social and economic life.

The concept of the globalisation of technology is rather difficult in that it seeks to

describe and explain how the process of economic and social globalisation is not only affected by, but is also itself affecting, the production, distribution and transfer of technology.[16] The strategies developed by both government and business institutions to generate technology are no longer based on a single country. Firms have to compete with a larger number of international rivals and this often compels them to up-grade their products and processes. Inward and outward technology spill-overs have also increased as a consequence of the enlarged market dimension.

The actors

The descriptions provided above indicate that these concepts of 'techno-nationalism' and 'techno-globalism' are of relevance for both public and business institutions, but also that these differing institutions will relate in their own ways to the processes under discussion. Public institutions typically operate at the scale of their own territorial state, yet are influenced heavily by the process of globalisation since the activities which take place within their own territory have effects beyond their borders and may in turn be challenged by decisions taken in other states.

National institutions at times compete to achieve leadership in science and technology (S&T), as was the case in the mid 1980s with the US Strategic Defence Initiative and the European Eureka programme.[17] In other cases, governments opt for cooperative strategies, as indicated by the large number of inter-governmental organisations in charge of specific international regimes. International property rights, international scientific exchanges, joint R&D programmes funded by international organisations such as the European Commission, and so on—all illustrate S&T governmental policies that are no longer simply national in scope.

The international orientation of firms is of course nothing new. One of the obvious ways for firms to grow has long been to export to overseas markets. In the post-war period, however, a more demanding form of internationalisation has gained importance, namely foreign direct investment (FDI), which implies the deployment of permanent facilities in host countries, which in turn obliges firms to become familiar with more than one national institutional system. Business companies have also developed other, more sophisticated forms of cross-border operation, such as joint-ventures, non-equity collaborations and so on. The extent to which firms are still 'loyal' to their own home country is a matter of debate. Some argue that multinational corporations have lost their national identity and pursue only their global strategies. Others point out that the competitive advantage of large companies is still linked to their home country.[18]

While governments cannot be seen as exclusively national agents, neither can firms be considered as stateless, and in spite of the increasing similarities of public and business actors as players in the domestic and foreign space, some basic differences persist: public institutions are by and large supposed to be accountable to their nation-based citizens, while business firms are allowed to be, and to some extent may be, accountable to stateless shareholders. This creates, at various levels, a complex web of interactions between inter-firm rivalry, on the one hand, and relations between nation states on the other. In order to expand their activities overseas, firms often seek the protection of foreign governments, although this in turn might jeopardise the relationship the firm has with their own home government—and such a process may also lead to a clash between the governments concerned. On the other hand, governments have to consider the pros and cons

associated with inward investment into their own country: foreign direct investment might upgrade their productive capacity but may also increase their dependency on foreign capital.

These issues are explored in a growing literature on international political economy and international relations, the implication of which is generally that governments and firms should select the capabilities to be developed in the home country, and those to be acquired in the international markets, when they deal with a strategic asset such as technological capabilities.[19]

The origin of the concept of National systems: Friedrich List

Is there a place in economics for the study of how nation-specific factors affect the structure of production, consumption and growth? Consider the Table of Contents from Adam Smith's *The Wealth of Nations* to Samuelson's *Economics*: we find 'the division of labour', 'the commodity', 'wages', 'profits', 'the laws of supply and demand', 'the supply of money' and so on. This reflects the way that economics has developed as an analytical rather than as a historical discipline. History has been allowed to enter only when extraordinary events such as the great crash or the post-war recovery needed to be interpreted.

In 1841 Friedrich List published his book on *The National System of Political Economy*, which even from the table of contents looked substantially different from the main Anglo-Saxon textbooks of his age. The first part was devoted to a discussion of the history of various peoples: the Italians, the Hanseatic League, the Flemish and the Dutch, the English, the Spanish and the Portuguese, the French, the Germans, the Russians, the North Americans. Economic theory proper was discussed *after* history in the second part of the treatise. It is no coincidence that List was German. At the beginning of the 19th century, German cultural life was dominated by the philosophy of history, which had as its main concern to explain and predict the rise and fall of nations.

Influenced by the rise of American society, where he lived for several years, List tried to provide an *economic* explanation for the changing positions of nations in history. He was convinced that economic life played a crucial role in it, and therefore he was highly critical of those German philosophers who ignored the material aspects of civilization. However, he also insisted that economic growth depended heavily on the social and cultural resources accumulated by a nation. Friedrich List can therefore be considered both a late member of the Germany philosophy of history and as a forerunner of the German historical school in economics.

Today, economists remember List as a fierce adversary of the theory of free trade as advocated by Adam Smith and his followers. It is certainly true that he was one of the few explicit supporters of trade protection—a doctrine that has received bitter criticism from economists, although less so from policy-makers and others. But in List's native town of Reutlingen, he is remembered as the pioneer of railways; he spent a large part of his life urging the princes who ruled 'the Germany of the one hundred homelands' to develop transportation. He understood that infrastructure, which in his day meant above all the railways, were a fundamental component of any strategy for economic growth since they allowed commodities, individuals and information to circulate.

To get a balanced view of List's ideas it is perhaps necessary to combine the reminiscences of economists with those of the inhabitants of Reutlingen. List was not in favour of protection for its own sake; rather, he understood that economic growth required the

creation of endogenous capabilities based on what he called 'intellectual capital' and learning.[20]

List's main concern could be formulated in a simple basic question: which strategies should a backward nation adopt to catch up with leading countries? The free circulation of commodities was hardly the right answer. The law of comparative advantage predicts that both the leader and the follower would gain from trade. List argued, however, that in the long run the former would be likely to have preserved its advantage, and the latter its underdevelopment. From a dynamic perspective, free trade would most likely preserve and expand inequality among nations.[21]

Relatively underdeveloped countries should accept free-trade policies only if the knowledge and expertise relating to the traded goods were equally freely traded. But this of course was not the practice followed by the then technological leader, the British Empire. In spite of the free-trade ideology espoused by the major English economists, the British government was keen to preserve its own technological leadership by hampering any transfer of knowledge to competing countries. Likewise, the trade of strategic machinery to other countries was heavily controlled by government policies.[22] A large part of List's life was devoted to the denunciation of this covert but tenacious British protectionism.

But List was also aware that the problems involved in the circulation and assimilation of know-how go beyond the attempts of the technological leaders to defend that lead. He also pointed out the objective asymmetry, that to transfer and assimilate knowledge is much more difficult and complex than is the trading of commodities. Even if the leading nations were prepared to share their know-how with catching-up countries, the latter would still have to devote substantial energies to attempt to assimilate it, including the development of their own endogenous scientific and technological capabilities.

List also understood that the development of endogenous capabilities had to be considered within the context of what was already in his day seen as the growing globalisation of economic activities. This offered an opportunity for late-comer nations to acquire best-practice techniques, although there was no guarantee that all nations would benefit to the same extent. On the question of how a late-comer could attempt to upgrade in the context of an increasingly global economy, he suggested four policy options:

- Investing in education to promote an adequately trained workforce.
- Creating a network of infrastructures to allow the dissemination of the most important economic resource, know-how.
- Creating economic ties among countries, such as customs unions. To strengthen their effectiveness, he also advocated the development of institutional systems of states.
- And then last and, actually, least—protecting infant industries to allow them to develop the expertise needed to face international competition.

National systems today

A century and a half after List, the concept of National systems of innovation is once again on the academic and policy-making agenda. The country case-studies published in Nelson's book[23] and the thematic issues discussed in the book from Lundvall[24] are reminiscent of, respectively, parts one and two of List's main work. Quite rightly, Chris Freeman starts his own historical journey on the nature of NSI from List's insights.[25] Taken

together, the resulting body of literature today on NSI identifies the following crucial aspects in defining the structure and explaining the behaviour of nations:

Education and training

Education and training are vital components of economic development. In spite of the international diffusion of education and of the increasing, although still limited, number of students enrolled in foreign universities, education is still largely national in scope. Substantial differences can be found between countries in the proportion of the relevant age group actually participating in education, whether in primary, secondary or higher. Moreover, the distribution of students by disciplines also varies markedly across countries, as shown with reference to the East Asian countries.[26]

Science and technology capabilities

The level of resources devoted by each nation to formal research and development (R&D) and other innovation-related activities (such as design, engineering, tooling-up, and so on) represents a basic characteristic of NSI. The bulk of the world's R&D activities is carried out in industrially advanced countries, while developing countries report a very small fraction of world R&D activities. Even within the relatively homogeneous group of OECD nations, there are significant differences in R&D intensity: a small club of countries, including the United States, Japan, Germany, Switzerland and Sweden, devote around 3% of their GDP to formal R&D activities. Other countries report a much smaller R&D intensity, although they might be less disadvantaged in terms of other innovative inputs. Another difference relates to how R&D expenditure splits between the public and the business sectors; big government programmes in space, defence and nuclear technologies often shape the entire structure of the science and technology (S&T) system of a nation.

Industrial structure

Firms are the principle agents of technological innovation. The industrial structure of a nation heavily conditions the nature of its innovative activities. Large firms are more likely to undertake basic research programmes, and are also more likely to be able to afford long-term investment in innovative activities whose pay-back may not only be spread years into the future, but may also be extremely uncertain. The level of competition faced by companies in their domestic market also plays a crucial role in the R&D investment outcome.

S&T strengths and weaknesses

Each country has its own strengths and weaknesses in different S&T fields. Some nations have specialisations in leading-edge technologies, while others have strengths in areas that are likely to provide only diminishing returns in the future. Moreover, some countries tend to be highly specialised in a few niches of excellence, while others have their S&T resources distributed more uniformly across all fields.[27] There are several determinants of National S&T specialization, including the size of a country, R&D intensity, market

structure, and the international division of labour. The resulting S&T specialization may influence a nation's future economic performance since countries with technological strengths in rising areas are likely to benefit from increasing returns, which in turn will allow them to expand their technological and production capabilities.

Interactions within the innovation system

The propensity of the different institutions to coordinate their activities and to interact with other actors differ widely across countries. Governments do interact heavily with large domestic firms (the so-called 'National champions') and the work of Fransman, for example, has detailed the workings of the Japanese Ministry for International Trade and Industry (MITI), one of the most cited successful institutions for the promotion of innovation in industry.[28] In other countries, small firms have been keen to share their expertise and cooperate in developing a common competitive strategy, as demonstrated by the Italian industrial districts. Such interactions are often able to multiply the effects of innovation undertaken at the country level and increase its diffusion. Its absence can hamper substantially the economic effectiveness of resources devoted to S&T.

Absorption from abroad

The operation of these various aspects of National systems of innovation need to be considered within the context of increasing international integration. In the post-war period, several countries have benefited from an international regime which has deliberately encouraged the international transmission of knowledge.[29] Some countries, especially in the Third World, have benefited from bilateral technology transfer. A general lesson drawn from recent research, however, confirms List's original insight that no technology transfer can be effective without an endogenous effort to acquire that knowlege.[30]

The list sketched above is far from being complete. Several other aspects would need to be added to provide a complete description of a national system. But the factors singled out above do indicate that the explanatory power of the NSI notion is of a *comparative* nature. The description of a specific National system is useful when it is compared with that of other countries. These comparisons can be either qualitative or quantitative. The qualitative approach was followed by, among others, Nelson, Freeman, and Porter.[31] Others have measured cross-country differences using indicators such as the level of resources devoted to R&D, the relative importance of the public and the business sectors, the level of international integration, and the distribution of the innovations produced across sectors.[32] However, we are still far from having achieved a coherent conceptual and empirical framework with which to explain the diversity between different countries' success in innovating.[33]

Implications of the NSI literature

The growing literature briefly discussed above makes clear that nations differ in their methods used to promote innovation and also in the quantity and significance of the innovations that have resulted from this effort. What are the implications of this for understanding the process of technological change, and for public policy?

First, while some of the key characteristics of innovative systems can be transferred from one country to another, others cannot be so easily transplanted, especially in the short term. Chris Freeman describes the way in which the decision by a few companies based in Germany and in the United States to establish internal R&D laboratories diffused gradually across several nations.[34] Yet more than a century later, the role of industrial R&D is very far from being uniform across countries.[35] Only in a few advanced countries is industrial R&D at the core of the innovation system. Thus the dissemination of basic institutional innovations (such as the development of a business R&D network, or state-promoted education, or the creation of major government-led technology-intensive programmes) often requires a substantial effort as well as considerable time to be replicated successfully in other countries. But not even time and effort can eliminate the continued existence of significant cross-country differences. The route which leads each nation to build its technological competence is highly path-dependent; this would not be surprising to philosophers of history nor to technology historians.[36]

Second, there is no one single model, which alone is able to deliver successful economic performance. Over the post-war period, Japan and Germany achieved high growth rates due in part to their massive investment in industrial R&D and technology. But other countries, such as Italy, managed to achieve the same goal while devoting a much lower effort to technology. There is more than one technological avenue leading to the wealth of nations.[37]

Third, nations which fail to exploit innovation can find themselves in an underdevelopment trap. In this context Chris Freeman discusses why it was that the Soviet Union and East European countries, in spite of their very high investment in R&D, failed to sustain their economic development.[38] He also compares Latin America to the countries of East Asia, pointing to a number of factors behind the industrial development of the East Asian economies that have been lacking in Latin America.

Fourth, historically a country's innovation system has often played an important part in securing and consolidating competitive advantage and can become the driving force for economic hegemony.[39] The change this century from British to American economic and political leadership was associated in part with the American capability to pioneer the systematic exploitation of knowledge in the productive system. The growth of East Asian countries has also been associated with their catching-up in a number of important technologies and to their acquired leadership in sectors of growing importance. The more innovative economies have also tended to be quick to adapt and imitate innovations produced elsewhere.

These implications drawn from the concept of NSI are, of course, based upon historical experience. Is there any reason to believe that the same patterns will continue in the future? There are two interrelated factors which might be thought to lower the importance of nation-specific factors in the future. The first is the existence of strong technology systems that tend to be similar across countries in spite of their differences. The second is the dissemination and transfer of know-how across borders which, in principle, would allow all nations to benefit from best-practice methods and techniques.

Technology systems versus National systems?

Rosenberg, Nelson and Winter, Dosi, and Freeman *et al*, all suggest that significant technological change is generally brought about as a result of specific regimes designed to

serve specific purposes.[40] A large number of technology and industry case studies have confirmed this to be the case.[41]

From a historical perspective, it is possible to identify technology systems which, even in the same periods, worked separately and independently. A thousand years ago basic agricultural techniques in China were quite different from those in Europe which in turn were different again from those in the Middle East. According to Gille, this was due to the lack of circulation of information as well as to institutional rigidity.[42] This is a far cry from the modern world system that has grown on the basis of the generation, circulation and diffusion of production techniques. The technical features of the majority of artifacts are similar across countries.

The similarities across technology systems are much broader than the narrow engineering characteristics of products.[43] Technology systems are also defined by industrial concentration, barriers to entry, industrial R&D intensity, and the methods used to secure returns from innovation. Malerba and Orsenigo show that the characteristics of technological areas in terms of concentration, industrial turbulence and innovative dynamism across the four main European countries are rather similar;[44] thus, in spite of the institutional differences of Germany, France, Great Britain and Italy,[45] some technology-specific elements tend to be surprisingly similar.

Does this consideration reduce the significance of nation-specific factors? According to Nelson:

> if one focuses narrowly on what we have defined as 'innovation systems' these tend to be sectorally specific. But if one broadens the focus the factors that make for commonality within a country come strongly into view, and these largely define the factors that make for commonality across sectors within a country.[46]

This view is confirmed by Costello, who compared the productivity growth of five major industries in six countries.[47] Her results demonstrated stronger correlations across industries within a country than across countries within the same industry. Thus, rather than seeing the concepts of technology systems on the one hand and national systems of innovation on the other as being alternatives, only one of which at most can be applicable, it appears to be the case, rather, that both technology-specific and nation-specific factors shape the innovative process. The organization of industry tends to be technology-specific, while the impact of innovation is heavily influenced by the overall national economic environment. The challenge for both theory and policy is to establish these interralations, and if possible to intervene to create positive feedbacks within this interrelationship.

What differentiates countries is not their methods of production in certain industries, but their relative strengths and weaknesses across industries. For example, the US innovation system is defined by strong government intervention in defense-related areas, and this is reflected in its sectoral strengths in aircraft and nuclear technology. Japan, on the other hand has negligible industrial activity in the aircraft sector. In spite of these differences, the industrial and technological features of the aircraft sector tend to be the same in both the US and Japan. However, it would be wrong to predict the sectoral specialisation of a nation on the grounds of institutional features alone: Italy, a country with medium R&D intensity and low industrial concentration is very active in automobiles, one of the industries generally associated with both high R&D and industrial concentration.

Is the globalisation of technology making the nation-state redundant?

The second factor which might be thought to diminish the importance of nation-specific factors is the increasing globalisation of technological and other industrial and economic processes. Several writers have stressed that we are experiencing a dramatic increase in the process of economic globalisation. International trade and capital flows, foreign direct investment, migration—all have increased substantially over the last 20 years.[48] A corresponding globalisation is said to have occurred in social, cultural and political life, impacting on local communities, including nation-states, and lowering ties of National identity, citizenship, and political sovereignty.[49] On the other hand, globalisation is certainly not a new phenomenon.[50]

We would make a distinction between three separate processes that are often subsumed within the catch-all general term technological globalisation.[51]

- International *exploitation* of national technological capabilities: firms try to exploit their innovations on global markets either by exporting products that embody them or by licensing the know-how.
- *Collaboration* across borders among both public and business institutions to exchange and develop know-how. Firms are expanding their non-equity agreements to share the costs and risks of industrial research.[52] Metcalfe points out that the scientific community has always been international in scope,[53] although public research centres and academia have recently increased their proportion of cross-border linkages substantially.[54]
- The *generation* of innovations across more than one country, which refers particularly to the activities of multinational corporations.[55]

On the first two of these dimensions to the globalisation of technology, it is hardly controversial that they have increased in importance. Trade and patent flows, international technical agreements and scientific co-authorships have all shown a dramatic increase over the past two decades or so. But it is intellectually sloppy to assume that this implies that nation-states have become less important in some way, without specifying the mechanisms by which this latter conclusion follows. If for example increased globalisation means that any loss of relative competitiveness translates into a far greater loss of markets—abroad and at home—with a concomitantly greater loss of jobs and threat to living standards than would have been the case in the days when the world economy was less 'global', then this would imply that the benefits from national action to enhance competitiveness would be that much greater, and conversely any inaction would risk far greater losses.

Certainly in this case, while globalisation may result in national action having greater payoffs—and national inaction greater costs—it could still be the case that although globalisation makes national action more rather than less important, at the same time it makes it more difficult, or less feasible. But again it is important not to jump to fashionable and easy conclusions unthinkingly. If national action has become more important yet more difficult, then this increased difficulty may itself call for more serious and far-reaching intervention from National governments to overcome such difficulties.

So while for the first two of our globalisation categories above the key controversy is over how to respond to trends which are reasonably well established (albeit exaggerated by some), on the third category of the extent to which multinational corporations

have increased their technological operations in host countries, the evidence itself is less well established. Patel, taking into account the patented inventions of more than 500 of the world's largest enterprises, shows that the vast majority of inventions are developed in the firm's home nation.[56] According to him, multinational corporations—the companies that by definition are globally-oriented—tend to be loyal to their own home-based country when they have to locate a strategic asset such as technology. However, these results presented by Patel appear at odds with those of Cantwell who, from a historical perspective, shows that the share of innovations generated by firms in host countries has increased considerably.[57]

Patented inventions, however, capture the most formalised part of technological knowledge only. Multinational corporations might be keener to decentralise forms of knowledge that do not belong to the core of their business strategy. Companies might be more willing to locate abroad facilities that are less critical to their strategy, such as software, engineering, design and so on. Less developed countries offer an adequately trained workforce, but at salaries that are much lower than in the developed countries, while information technologies make the geographical location of high-tech jobs less relevant. This justifies the widespread concern that industrial countries could lose skill-intensive jobs to the benefit of the South.[58]

On what might induce companies to centralise or decentralise their technological activities, Howells and Wood suggest that the advantages of centralisation include: the benefits of economies of scale and scope that are associated with larger R&D operations; the minimum efficient size that is associated with indivisibilities of certain scientific instruments and facilities; the increased security over in-house research, which amongst other things reduces the risk of competitors copying or leap-frogging in key research fields; and the ability to create a well-established dense local innovation network with higher-education institutes, contract research companies and other support agencies.[59] The main advantages they see associated with decentralisation are: a more effective and applicable R&D effort focused on the actual needs of the business and operational units; improved communications or coupling between R&D and other key corporate functions; less problems in 'programme dislocation' when a project is transferred from R&D to production; and better responsiveness to various local market needs. To this list might be added: to keep a window open on the technological developments of other countries; and to take advantage of the fields of excellence of the host country.

An extensive survey of companies' headquarters and host facilities has identified the type of work undertaken in overseas R&D laboratories.[60] The most frequent activities carried out in host countries are to derive new production technology and to adapt existing products to the local markets to make them accepted by local communities. Even the taste of Coca-cola, the most typical standardized product of the global economy, is not quite the same in the USA, Japan and Italy.[61]

Multinational corporations apply a variety of strategies to capitalize on their technological advantages. Bartlett and Ghoshal have provided a useful categorisation of three different, although not mutually exclusive, strategic approaches:[62]

- *Centre-for-global.* This is the traditional 'octopus' view of the multinational corporation: a single 'brain' located within the company's headquarters concentrates the strategic resources: top management, planning, and technological expertise. The brain distributes impulses to the tentacles (that is, the subsidiaries) scattered across host coun-

tries. Even when some overseas R&D is reported, this is basically concerned with adapting products to local users' needs.

- *Local-for-local.* Each subsidiary of the firm develops its own technological know-how to serve local needs. The interaction among subsidiaries is, at least from the viewpoint of developing technological innovations, rather low. On the contrary, subsidiaries are integrated into the local fabric. This may occur with conglomerate firms or companies which are not characterised by strong global products.
- *Local-for-global.* This is the case of multinational corporations which, rather than concentrating their technological activities in a home country, distribute R&D and technological expertise in a variety of host countries. This allows the company to develop each part of the innovative process in the most suitable environment: semiconductors in Silicon Valley, automobile components in Turin, software in India. The effectiveness of such a strategy relies on the intensity of intra-firm information flows.

Techno-nationalism versus techno-globalism?

Much of the debate about techno-nationalism and techno-globalism has direct policy implications, explicitly addressed by Fransman and Metcalfe.[63] What is the point of government policies to promote innovation in industry if the benefits can be transferred to other countries? Is there any guarantee that firms will use these benefits to the advantage of the nation that provides support? For example, Reich argues that it is not in the interests of a nation to support National champions. He advocates instead policies to foster the infrastructure of a nation:

> Rather than increase the profitability of corporations flying its flag, or enlarge the worldwide holdings of its citizens, a nation's economic role is to improve its citizens' standard of living by enhancing the value of what they contribute to the world economy. The concern over national 'competitiveness' is often misplaced. It is not what we own that counts; it is what we do.[64]

In the US in particular, there has been widespread concern that government policies could be benefiting foreign firms just as much as domestic ones. For example, much of the US government funded defence and space R&D in semiconductors was exploited by Japanese companies to develop high-tech competitive products.[65] The US and other industrial countries have therefore called for a more tightly regulated international regime of intellectual and industrial property rights. In other words, the focus has shifted from the generation of technology to devices to guarantee sufficient returns from it on international markets.[66]

This has implications for industrial and technology policy. Metcalfe differentiates between two broad categories of government action, namely direct financial incentives to companies for their innovative programmes, and public supply of infrastructures to make a country attractive for the deployment of S&T activities.[67] Globalisation may be thought to have reduced the usefulness of the first kind of government policies, especially when the benefits are received by companies with subsidiaries in several countries. But policies of the second kind, which include education, effective industry–university partnerships, communications and so on have certainly increased in importance.[68] In the global economy, nations have to upgrade their infrastructure to attract technology-intensive activities. Fransman, after describing the activities of the Japanese MITI, asks: how could MITI have so much power with such a small amount of financial resources?[69] The

question itself indicates that policies aimed at creating an innovative and industrially dynamic environment can be much more important than simply handing cash to companies.

An essential factor in the post-war 'golden age of capitalism' was the existence of an international regime favourable to the diffusion of S&T.[70] But today any such regime appears to be under constant threat from the operation of large corporations.[71] From this perspective, the real opposition to *techno-nationalism* is not, as is so often suggested *techno-globalism* but rather *techno-liberalism.* It is therefore no surprise that the literature on National systems generally advocates a stronger role of government to foster innovation.[72]

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