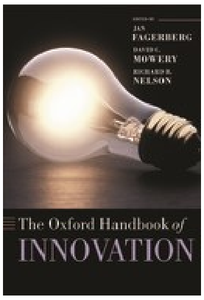

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CHAPTER

20 Innovation and Competitiveness

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Abstract

Competitiveness derives from the creation of the locally differentiated capabilities needed to sustain growth in an internationally competitive selection environment. Such capabilities are created through innovation, and because capabilities are varied and differentiated, and since the creative learning processes for generating capabilities are open-ended and generally allow for multiple potential avenues to success, a range of different actors may improve their competitiveness together. According to this article, the efforts to promote competitiveness through innovation can rarely be understood in isolation from what others are achieving at the same time. This applies whether one is speaking of countries, of national groups of firms in an industry, of subnational regions, or of individual companies. Indeed, it is worth emphasizing that the degree of interaction between innovators in search of competitiveness has tended to rise substantially historically, and has attained new heights in recent years.

Keywords: competitiveness, innovation, multiple potential avenues, national groups, subnational regions

Subject: Business Strategy, Innovation, Business and Management

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20.1 Introduction

TRADITIONALLY, economists and economic historians since Adam Smith have discussed economic growth principally in the context of the national level—why some countries grow faster (in modern terms, acquire the capabilities for sustained growth that make them more competitive) and so become wealthier than others. While in neoclassical economics questions of national competitiveness came to assume a lesser degree of importance, as attention was shifted away from issues of growth towards those of static resource allocation and efficiency, there was even less concern with the notion of competitiveness at the firm level. The theory of the (comparative) growth of the firm was a minority interest of those such as Downie (1958), Penrose (1959), and Marris (1964), typically treated as a rather esoteric sub-branch of industrial economics, that was to be accorded a lesser status in the discipline than the conventional theory of the firm (which was really a theory of the relationship between the firm and markets). In recent years two related changes in economics and allied areas of research have been under way. One is a revival of a more widespread interest in the classical issues of competitiveness at a national level, and the other is the growing attention now paid to competitiveness at the level of industries, regions, and firms, in which fields of research a substantial new literature p. 544 ↳ has emerged. In Section 20.2 the contribution is assessed of the new literature on competitiveness across countries. Section 20.3 examines innovation and competitiveness at the industry level that connects together firms and their environment, and Section 20.4 looks at the regional and firm level. Section 20.5 draws some conclusions with respect to the interaction between innovative actors, between the different levels of analysis of competitiveness, and opportunities for future research.

Competitiveness is here taken to mean the possession of the capabilities needed for sustained economic growth in an internationally competitive selection environment, in which environment there are others (countries, clusters, or individual firms, depending upon the level of analysis) that have an equivalent but differentiated set of capabilities of their own. The term competitiveness is also sometimes taken to necessarily imply as a result a continuing rise in the living standards of the individuals that are members of a social group with the required capabilities (notably in this context, to imply a sustained increase in the living standards of the citizens of the country that is suitably competitive in world markets—see Tyson 1992). While it is indeed necessarily true that productivity growth increases incomes on average (i.e. per capita income), it may well be that the process of capability generation and growth also has a disruptive effect on the distribution of incomes. This issue is not addressed directly here, since the way in which innovation affects the employment opportunities of individuals, which is a major influence upon their respective earning capacities, is the subject of Pianta (Ch. 21 in this volume).

The winners from innovation are those that construct appropriate capabilities, but capabilities are localized and nationally differentiated (as explained by Edquist, Ch. 7 this volume), and so there can be many successful players in the competitive game, each to some extent learning from and interacting with the somewhat alternative paths to capability creation being taken by others. Put in these terms few could object that the pursuit of competitiveness through innovation is a laudable objective of national policy, and indeed an increasingly important objective as the role of innovation has risen in the modern knowledge-driven economy, even for (actually especially for) countries that start behind and wish to catch up (Fagerberg and Godinho, Ch. 19 in this volume).

To be meaningful, competitiveness must be thought of as entailing a relative comparison of growth rates or benchmarking of performance to assess how well each participant has done in developing the capabilities for innovation and growth, and not be about the mutual potential for damaging one another (a misleading interpretation of competitiveness criticized by Krugman 1994*a*, 1996). It is reasonable to expect that, at least on average, the spillover benefits for others of a good performance in one location or by one agent tend to outweigh the costs of that good performance for others. This argument is largely applicable whether the unit of analysis is countries in the world economy or firms in an industry. At a country level the efforts of

each national system of innovation to promote the competitiveness of businesses sited locally are
p. 545 increasingly complementary as scientific and engineering ↳ communities become more international, and cross-border knowledge flows are more common (as discussed by Narula and Zanfei, Ch. 12 in this volume). Likewise, much of the growth achieved by the leading corporations in an industry reflects the wider growth of that industry. The competitive race between firms stimulates innovation, and this innovation lowers costs and improves product quality in the industry, and thereby increases industry demand. All firms benefit that contribute successfully to what is often a combined and interactive process of innovation.

20.2 Competitiveness at the National Level

When looking at the country level, competitiveness is about the way in which the pattern of international trade evolves over time to reflect changing patterns of capabilities and hence competitive advantage (what might be thought of as the evolution in the comparative advantage of countries), rather than about the established pattern of comparative advantage which is the usual focus of trade theory. While the earliest theories of trade and growth can be traced back to the classical economists, such dynamic accounts of the paths of international trade and investment were revived in recent times by the technology gap approach (Posner 1961) and the product cycle model (Vernon 1966). However, a major shortcoming of the product cycle model was its reliance upon an overly simplistic demand-driven theory of innovation (which reflected the spirit of the 1960s, when it was devised), through which the firm was assimilated to the product, and innovation was supposed to be concentrated in just one leading country—the US (see Cantwell 1989, for a further discussion of the model). Sadly, when the product cycle model broke down in the 1970s, in large part owing to the reemergence of multiple centers for innovation in a number of international industries, the amended versions of the model (Vernon 1974, 1979) focused upon considerations of oligopolistic strategy rather than revisiting the underlying theory of innovation and competitiveness. It was only in the 1980s that scholars based at Sussex once again wedded an analysis of structural shifts over time in the pattern of international trade to a more realistic approach to innovation: see Soete 1981; Dosi and Soete 1988; Dosi, Pavitt, and Soete 1990; and Fagerberg's 1987 paper on structural changes in international trade (repr. as ch. 7 in Fagerberg 2002).

Part of the inspiration for Fagerberg's research had been that economists sometimes use the term "competitiveness" in various different ways, and especially in macroeconomic policy discussions not
p. 546 always in the way that has been defined here. ↳ This chapter is concerned with innovation and competitiveness, and this is sometimes distinguished as being about longer-term technological competitiveness, as opposed to shorter-term price competitiveness. There are two different ways of discussing competitiveness in the latter sense of shorter-term price competitiveness. In the context of conventional demand management policy discussions, if (say) lower government borrowing means a fall in interest rates and so a rise in net outward investment, and if this leads to a decline in the value of the domestic currency, then the price "competitiveness" of domestically produced goods and services can be said to have increased, as export prices fall in foreign currency terms while import prices rise in domestic currency terms. However, this type of competitiveness is unlikely to be sustainable, especially if (for example) the rise in import prices sparks off domestic inflation, or if lower net inward investment has adverse consequences for domestic productivity growth. The second and for our purposes more substantive context is the conventional cost-based account of competitiveness, in which a fall in relative unit labor costs means lower prices (or a lower rate of inflation), which in turn leads to a rise in exports and fall in imports, and so an increase in the value of the domestic currency.

Longer-termtechnological competitiveness is more akin to the second of these two versions of price competitiveness, in supposing that a faster growth of (output and) exports drives up the domestic currency, rather than it being a falling currency that promotes net exports. In the context of what is sometimes termed “non-price” competitiveness to distinguish it more clearly from the kind of cost-based competitiveness just referred to, innovation and new lines of value creation may mean higher average prices as an indicator of higher quality, but in any event they lead to a faster growth of productivity and trade, and thus an upward trend in the value of the domestic currency. Given what has been said already, it is worth stressing here that in this perspective the rise in the value of the currency is simply the reflection of competitiveness, defined as a relatively rapid growth in productivity and the value of (output and) exports. The rise in the value of the domestic currency is not itself the achievement of competitiveness (an improvement in the terms of trade that is essentially a potential side effect resulting from competitiveness). It is also worth making explicit that the departures from comparative advantage associated with trade imbalances are merely a temporary result of competitiveness in this framework, and again not in themselves the objective of competitiveness. What is implicitly supposed here is that faster productivity growth is associated with a rising share of world trade, and that in this process the growth of exports leads the growth of imports. So net exports rise until imports catch up, and this catching up is facilitated by the consequent rise in the value of the domestic currency and in domestic wage rates.

Now neo-Schumpeterian approaches to international competitiveness focus on this kind of process of forging technological competitiveness, which for those whose innovative efforts are most successful implies a sustainable increase in the share of world trade (or at the firm level, a sustainable increase in the
p. 547 share of the relevant ↳ world market). However, as has been discussed at length already, in the Schumpeterian perspective competition entails the positive sum game of establishing new spheres of value creation, so innovations expand the overall magnitude of world trade and the world market. Those that contribute most to this process of expansion see their shares rise as they are responsible for more of the new element of value creation, and not because of a substitution effect within some fixed total level of world trade or some fixed and given world market (or even within some steadily exogenously growing world market). In this context, the neo-Schumpeterian analysis of innovation and competitiveness is unlike equilibrium growth accounts, even when those accounts incorporate an acknowledgement of research activity, if investment in innovation is treated as being inherently like investment in any other economic activity, and if the only difference between activities is treated as lying in their wider impact on other activities through externalities. Instead, in the neo-Schumpeterian story the very nature and purpose of innovative activity is to disturb and add to the existing circular flow of income generation, in an experimental and non-equilibrium fashion.

Such neo-Schumpeterian models of innovation and growth might be specified in at least two alternative ways. The first of these leans heavily on the distinction just drawn between shorter-term price competitiveness and longer-term non-price technological competitiveness. In Fagerberg's (1987, 1988) technology gap formulation of international competitiveness across countries, the impact on growth of national rates of innovation and distance behind the technology leader are treated primarily as additive elements, to be added on to the more traditional determinants of economic growth in the form of capital accumulation (the share of investment in national output) and relative unit labor costs. The origins of viewing cross-country growth in this kind of additive framework can be traced to Abramowitz (1956), Solow (1957), and Denison (1967), for whom technological improvements (and the productivity growth to which they led) were an obvious means of accounting for the substantial “residual” in variations in growth that remained after allowing for the effect of the increase in factor inputs. So in this context capital accumulation proxies for the extension of the scale of established activities, relative unit labor costs capture cost-based “price” competitiveness, while the contribution of corporate research and the capacity to catch up through imitating the achievements of a leader represent “non-price” technological competitiveness.

Setting the problem up in this way is convenient, as the empirical evidence then generally suggests that technological competitiveness is more important than the more commonly considered traditional influences upon competitiveness. Technological competitiveness is judged to be more significant than

relative unit labor costs; although Krugman (1994*b*) and Young (1995) point to the continuing importance of capital accumulation within this kind of framework. The evidence for three countries—Japan, the UK, and
p. 548 the US—over the period 1960–73 is illustrated in Table 20.1. Based on the estimation of his empirical model of international ↳ competitiveness, Fagerberg (1988) was able to decompose the model's predicted change in each country's share of world trade (which were reasonably good predictions of the actual changes in market shares) into four elements, as shown. What emerges is that the traditional consideration of relative wage costs contributed rather little to overall competitiveness in any of these countries (although it was statistically significant in all the equations of the model in which it appeared). In contrast, the growth in indigenous technological capabilities in Japan, and the diffusion of foreign frontier technologies, account for a good deal of the Japanese competitive success of that period. The loss of world trade shares by the UK and the US over the same period can be attributed mainly to weak capital accumulation, and Fagerberg explained this mainly by the drain placed on national resources by the high shares of military spending in these two countries.

Table 20.1 The decomposition of the predicted growth in national market shares from an estimated empirical model of cross-country competitiveness, for 1961–73 (%)

	Japan	UK	USA
Growth in technological capabilities	66.9	6.9	−0.6
Rise in relative unit labour costs	−0.9	0.8	1.6
Initial technological capabilities (catch-up)	20.9	15.9	7.3
Investment as share of GDP, and growth of world demand	16.5	−39.8	−38.2
Total growth in market share (predicted by model)	103.3	−16.2	−29.8

Source: Fagerberg (1988).

However, when capital accumulation contributes positively to a favorable growth rate, at least some element of it reflects the establishment of new fields of activity, and is a response to the creation of new innovative opportunities. Therefore, it is not clear that the contribution of the growth of traditional factor inputs can really be cleanly distinguished from that of innovation, unlike in the logic of a standard production function approach. So to exclude capital accumulation from the contribution of technological competitiveness provides only a conservative lower bound estimate of the significance of the latter, and perhaps concedes too much to orthodox skeptics of the role of innovation in growth and competitiveness. Fagerberg (1988) was aware of this issue, and so he included a separate equation in his simultaneous system for capital accumulation as a function of the growth of output, which in turn depended as we have seen upon
p. 549 the increase in technological capacity, so that he ↳ acknowledged indirectly the influence of technological competitiveness upon capital investment. This need to revise the traditional production function logic becomes especially relevant when trying to compare innovative or technological “assimilationist” explanations of (East Asian) competitive success with those of “accumulationists,” if using aggregate measurements in the context of substantial structural change (Nelson and Pack 1999). As we have already noted, neo-Schumpeterian economists have particularly emphasized the connection between structural change and growth through innovation.

Some evidence on what distinguished the East Asian growth experience from that of other countries that sustained similarly high rates of capital accumulation over the 1960–89 period is set out in Table 20.2. The table shows eleven countries that enjoyed very high shares of investment in GDP, of over 20 per cent, as indicated in the first column. The right-hand column shows the residuals of a regression across 101 countries of GDP per capita on the investment share as a proxy measure of the rate of capital accumulation, and on three other control variables (a catching-up effect proxied by the intial level of GDP per capita in 1960, the growth of population to capture the availability of labor supplies, and the proportion of the relevant cohort of the population educated to at least secondary school standards). This was part of the study of Nelson and Pack (1999). What emerges is that among high investment countries, the East Asian tigers—Hong Kong, Korea, Singapore, and Taiwan—stand ↳ out as managing to achieve growth rates well
p. 550 in excess of what might have been predicted from their favorable rates of capital accumulation alone. What was different in these economies was their greater ability to innovate, to upgrade and restructure their indigenous industries, and to learn and absorb more effectively from foreign technologies. Capital accumulation can embody innovation to the extent that it is linked to the transformation of the productive activities being conducted.

Table 20.2 Actual growth rates achieved by countries, 1960–89, over and above that predicted by (*inter alia*) their rates of capital accumulation

	Investment/GDP (%)	Actual minus predicted growth rate of GDP per capita
Hong Kong	27.3	0.031
Korea	24.9	0.032
Singapore	34.3	0.017
Taiwan	25.0	0.047
Gabon	40.0	−0.030
Algeria	35.0	−0.026
Greece	24.2	0.008
Panama	24.0	0.002
Portugal	23.7	−0.002
Jamaica	25.0	−0.037
Ireland	22.2	0.011

Source: Nelson and Pack (1999).

So an alternative approach also in the Schumpeterian tradition is to treat technological accumulation and capital accumulation as simply aspects of a common process, rather than as independent (even if complementary) contributions to growth. In this case innovation can be seen as driving up profitability and hence lowering the share of wages in output (even though wages are rising faster, and so may be unit labor costs), which leads to a higher share of investment in output, and so higher capital accumulation and growth as a result of higher technological accumulation (Cantwell 1989, 1992). The basic idea here is that in fast-growing countries just as an increase in imports tends to follow an increase in exports with a lag, so wages tend to follow productivity increases with a lag, enabling innovation to create a fresh source of profitability and growth. Yet this also suggests that technological competitiveness is in part cost-based. It should be noted, though, that labor productivity is defined here simply as the value of output per worker employed, which implies that productivity growth is as much attributable to product quality improvements (that raise the value or unit price of output, as stressed in Fagerberg's approach), as it is to the cost reductions associated with process improvements. In this alternative neo-Schumpeterian formulation we need worry less about the distinction between embodied and disembodied technological change, or the distinction between improvements in product quality and delivery times as opposed to improvements in processes that are reflected in costs and prices.

The renewed interest in international competitiveness and variations in growth rates has spawned a substantial new literature on cross-country convergence or catching-up versus divergence or falling-behind (see e.g. Baumol, Nelson, and Wolff 1994). The evidence suggests that whether one observes convergence or divergence depends upon the period studied and the countries selected. In any case, the overall trend in cross-country variance at a world level may not be the most important issue. Rather than trying to work out whether East Asian convergence statistically outweighed the effect of African divergence in aggregate, the issue is more why and how firms in East Asia had the capabilities to catch up in the period since 1960, while those in Africa did not. The concepts of a techno-socio-economic paradigm (Freeman and Perez 1988), or of an evolution in the institutional characteristics of capitalism (Lazonick 1991, 1992), can be useful in this respect as a means of explaining occasional shifts in technological leadership or longer term competitiveness, and in the direction of those shifts. Emphasizing again the role of structural change
p. 551
in growth, and in particular during periods of paradigm change, when the prevailing ↳ characteristics of innovation undergo transformation, helps to explain the existence of windows of opportunity in which the catching-up of selected countries may be especially dramatic. At these times leaders can have special difficulty in adjusting to the new conditions since they have become most locked in to the types of innovation favored under the earlier paradigm, while others that lie behind initially may find that their rather different institutions and methods of social organization are in fact quite well suited to adapting so as to promote just the kinds of structural change in which lie now the greatest opportunities for fresh innovation.

20.3 Competitiveness at the Industry Level: the Nexus of Relationships between Firms and their Environment

When speaking of shifts in competitiveness between firms or between different national groups of firms that constitute the major players in an international industry, Mowery and Nelson (1999) prefer the term industrial leadership, so as to emphasize that such leadership may be due as much to the national or regional environment in which firms operate, or to institutions that are specific to an industry, as to factors that are purely internal to the firms in question. From detailed historical case studies of the evolution of national industries, they conclude that competitiveness derives from the contributions of each of, and the interactions between, firms, regions, and countries, and the sectoral support systems that connect these different levels of analysis. Their account provides a clear justification for a section that covers competitiveness at the international industry level, rather than attempting to move directly from the country level to the firm level.

In this framework the factors that are thought to influence competitiveness may be grouped under the headings of resources or capabilities, institutions (notably for higher education and science, and in financial systems), markets or demand conditions, and inter-company networks. Models that are based at the level of the evolution of particular products or technologies, or which are predicated on a notion of competence-destroying innovation (when moving from one type of product or technology to another that represents a radical departure from the past), may each have some relevance. Yet Mowery and Nelson argue that this applicability is limited when dealing with the performance of largemultiproduct firms over very long periods of time. Likewise, the policy debate surrounding the relationship between government policy interventions and trends in competitiveness is overly polarized, when each side p. 552 ↳ of the debate has in mind a rather simple model of that relationship (or lack of a relationship) which may apply at some places and at certain times, but cannot be universally applied in the way that some advocates seem to imagine.

The relationships that exist between the development of the technological capabilities in firms that are responsible for competitiveness and the institutions of the wider society vary from one country to another, but in particular they tend to be different in countries that belong to an already leading industrialized group and those that are attempting to catch up with them (see also Fagerberg and Godinho, Ch. 19 in this volume). It is noticeable that there have been a greater number of cases in which governments in catching-up economies, partly through measures of domestic protection, have contributed more actively to the fostering of capabilities in local infant industries and in indigenous companies. This was true of the US and Germany when they were catching up with Britain in the nineteenth century (Landes 1969), it was true of Japan when it was catching up with the West during the twentieth century (Ozawa 1974), and it was true of Korea when it was catching up after 1960 (Enos and Park 1988). It is true that there are occasionally other cases of catching-up economies, like those of Singapore or Mexico in recent years, that have taken advantage instead of various aspects of trade liberalization. However, what is most noticeable in all these instances of successful catching-up is that the trade policies of governments were merely part of a much wider package of support for the longer term nourishment of capabilities in indigenous firms. Since the emergence of science-based industries towards the end of the nineteenth century this has meant especially investing in science and higher education, in the training of engineers, and in the learning of skills more widely (Freeman and Louçã 2001). Equally important, where there were measures of trade protection local firms accepted their part of the bargain to invest very substantially in capability creation in an outward-looking and export-oriented fashion, rather than simply remaining an inefficient enclave as in so many other cases of protectionism or so-called import-substituting industrialization.

Of course, the institutional structures of catching-up economies changed markedly (and any protectionist measures were largely reversed) as their firms caught up and themselves sometimes forged ahead and became innovative leaders in their own right. This is perhaps the most vivid illustration of the general observation that the development of technological capabilities in firms and the character of the institutions that support these competitive efforts in the wider society tend to coevolve with one another (Nelson 1995), through a process of continual interaction. Another perspective on these interrelated national systems for the construction of competitiveness is offered by Porter (1990), as represented through the four corners of a diamond of factor conditions; demand conditions; related and supporting industries; and firm strategy, structure, and rivalry. In Porter's view the capacity of firms to innovate depends critically on having sufficient domestic rivalry in their own home country of origin, but also on the presence of spillovers between firms associated p. 553 ↳ with localized clusters (to which issue we return below). In other words, innovation requires an appropriate mix of interfirm rivalry and cooperation or exchange (Richardson 1972). Lazonick (1993) has argued that when confronted with a major new competitive challenge from some new source of innovation from outside, domestic industries may need to shift this balance away from rivalry and towards cooperation in order to respond effectively. To express this another way in the light of the trend towards globalization mentioned earlier, it may be that firms in some national industry may need to increasingly collectively focus their efforts in what they do locally (as opposed to activities they may locate abroad) to be better mutually aligned with whatever may be the fields of particular local excellence or of specialization in innovation. This would have the effect of tending to reinforce national patterns of comparative advantage in innovation.

As has been mentioned already, with the emergence of science-based industries over a century ago, the need for an infrastructure that suitably supports relevant education, skill formation, and training became critical to the competitiveness of industries, and iswidely believed to have become more important still in the modern techno-socio-economic paradigm associated with computerization and information processing. For firms to be able to create capabilities requires costly and difficult internal learning processes, but these in their turn depend upon having suitable organizational and technical skills in the management and workforce on which they rely. The composition of skills in the workforce of the home base of firms is therefore critical to the success or failure of countries that are trying to catch up, but it also becomes a central influence upon the fields in which any national group of firms has its specific pattern of comparative advantage in innovation and capability creation. Of course, this is not just a one-way street, since the types of investments and commitments to training that are made by firms themselves in the course of learning, the professional associations they help to form, and the pressures they place upon governments and others imply again a process of coevolution between firms and their environment in this respect too.

Table 20.3 helps to illustrate the significance of education and skills in the catching-up of the four East Asian tiger economies (see also Fagerberg and Godinho, Ch. 19 in this volume). Korea stands out as having surpassed even the commitment of the traditional industrialized countries to higher education in the natural sciences and mathematics. Yet a key to the success of these countries as a group lies more in the investments they have undertaken in support of engineering graduates—while Hong Kong lies behind the industrialized group (and this may help to account for why its local learning and upgrading has been more limited than in the other three, as discussed by Lall 2001), Singapore is above the industrialized country average, and Korea and Taiwan are way ahead of that average for tertiary level engineering enrolments as a proportion of the population. Other developing countries are generally well behind the achievements in engineering education of the tiger economies, although the Philippines, Argentina, and Mexico have at least matched the p. 554 ↳ position of Hong Kong. Considering the enormous size of its population, it is also clear that China has been catching up fast in this area.

Table 20.3 Educational enrollments in technical subjects at tertiary level as a % of the total population in selected countries, in 1995 or closest year available

	Natural science, maths and computing	Engineering
Japan	0.07	0.39
France	0.53	0.09
Germany	0.39	0.49
UK	0.31	0.38
USA	0.39	0.31
Hong Kong	0.20	0.25
Singapore	0.10	0.47
Korea	0.56	0.98
Taiwan	0.24	0.86
Indonesia	0.02	0.11
Malaysia	0.07	0.07
Philippines	0.22	0.33
Thailand	0.14	0.19
China	0.03	0.10
India	0.10	0.02
Argentina	0.21	0.29
Brazil	0.09	0.10
Mexico	0.06	0.27

Source: Lall (2001).

The Japanese and German systems are known to focus on a broad and deep skill base by emphasizing the acquisition of general engineering skills and the good standard of basic education of the population as a whole, while the US and UK systems tend to be more elitist and focus on the development of higher-end skills over a narrower range of people (Prais 1995; Lazonick and O'Sullivan 1997; Lazonick 1998). This helps to explain why the Japanese and German fields of comparative advantage in innovation (and thus, of competitive advantage) include motor vehicles and engineering that rely (and have increasingly come to rely) on a broad ↳ skill base, while the US and UK advantages include aerospace, software, pharmaceuticals, biotechnology, and medical equipment that rely on very highly skilled individuals and an intensive R&D effort.

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When examining the extent of path-dependency in the specific technological traditions of national groups of large firms, and in their patterns of technological specialization as a measure of their relative contributions to each of the major international industries (the cross-sectoral pattern of their technological competitiveness), some cross-border interdependencies appear to emerge. This raises again the issue of whether or not there have been any elements of convergence across countries, but in this context in the specific mix of strengths and weaknesses in international industries, rather than in aggregate productivity or performance. Examining patterns of technological specialization among national groups of the largest firms from six countries (the US, Germany, the UK, France, Switzerland, and Sweden) based on their patterns of corporate patenting, it has been observed that these profiles are path-dependent and tend to persist to some extent even over periods of sixty years, from the interwar period to the present day (Cantwell 2000). This may be taken to imply that the positive effect on the continuity of collective technological trajectories of intercompany technological cooperation and spillovers within national groups has tended to outweigh the negative effect of mobility in cross-company distributions of activity. There is some evidence that through the evolution in these patterns of technological competence that has occurred, certain national groups have come somewhat closer to one another than they were in the past, or they have changed in similar ways. Indeed, it might be argued that the six national groups examined can now be divided into three clusters of two countries each.

The first cluster comprises the largest US and UK firms, in which the profile of technological competence can be characterized as being resource-based, oil-related, and defence-related. It is increasingly also health-related. As shown in Table 20.4, in the US case since the interwar period a continuing comparative advantage in innovative activity in the largest industrial firms has been sustained in the oil, food products, rubber products, aerospace (defence and larger-scale transport systems) and building materials industries. The greatest continuing strengths for the largest British companies over the same historical period has been in textiles, other transport (defense) and oil since the 1930s. Thus, it can be argued that there has been some convergence in the profiles of the US and UK innovation systems (Vertova 1998). UK firms have also seen a post-war shift into technological competence in the pharmaceutical industry, although it can be claimed that this too represents the revival of a much earlier nineteenth-century tradition in biological and medical technologies. In any event, consistent with the overall UK or US pattern of technological development, the British pharmaceutical industry had links with the food industry, unlike in Germany where it derived purely from the chemicals industry (Cantwell and Bachmann 1998). In the US there has been a related post-war ↳ continuation and strengthening of the medical instrument industry (grouped under professional and scientific instruments in Table 20.4), and a more recent move into biotechnology, although this has not yet been reflected in a comparative advantage in the pharmaceutical industry as a whole.

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The second cluster is that of the German-and Swiss-owned corporate groups, in which technological development since the end of the nineteenth century has been largely science-based, and revolved around the dominance of the chemicals industry. In the post-war period this has been increasingly complemented by engineering excellence, although some recent commentators have seen this direction of change (as opposed to a move into the other science-based area of electronics) as a weakness of the modern German innovation system (Albach 1996; Audretsch 1996). The leading German firms have held a consistent focus on development in the chemicals and metal product industries, with some recent shift towards industries more reliant on engineering-based technologies, linked in part to the emergence of a wider range of innovative smaller specialist supplier companies. The Swiss concentration historically p. 557 on chemicals and pharmaceuticals makes it a microcosm of (part of) the German innovation system, which has also been shifting in the direction of engineering excellence.

Table 20.4 The industries in which the largest nationally owned firms have persistently held comparative advantage in innovation, 1920–39 and 1978–95

US-owned	**UK-owned**
Food and drink	Textiles
Office equipment and computing	Other transport equipment
Other transport equipment (other than motor vehicles)	Coal and petroleum products
Rubber and plastic products	
Non-metallic mineral products	
Coal and petroleum products (oil)	
Professional and scientific instruments	
German-owned	**Swiss-owned**
Chemicals	Chemicals
Pharmaceuticals	Pharmaceuticals
Metal products	Mechanical engineering
Motor vehicles	
French-owned	**Swedish-owned**
Metal products	Mechanical engineering
Rubber and plastic products	
Non-metallic mineral products	

Source: Cantwell (2000).

The third cluster may be more a matter of coincidence than due to any historical, geographical, or cultural ties, involving as it does the French and Swedish national groups of companies. This grouping has emphasized infrastructural types of technology, spanning engineering, construction, transport and communications systems, and some recent moves into health care. In the French case comparative advantage in large firm innovation has been sustained since the interwar years in metal products, rubber products, and building materials, while some earlier strengths in electrical communications technologies have been subsequently consolidated. This infrastructural orientation is less reliant upon large-scale private corporate R&D than the German system has been, but is not as resource-oriented as the US or UK company systems of technological development. Swedish technological excellence has also been engineering-based (and has become increasingly so) around the metals and vehicles industries, but it has been shifting more closely towards the French pattern with the recent rise of development in the areas of telecommunications and pharmaceuticals.

The apparent convergence of certain national systems of large-firm innovation with continuing differentiation between these clusters of groupings may be an aspect of the rise in technological interrelatedness and interlinked systems of technologies, which have eroded the more highly specialized national systems of the past. Hence, the significance of technological lock-in and path-dependency in each respective system has still been accompanied by some selected convergences between particular national groups.

20.4 Competitiveness at the Regional and Firm Levels

The significance of the "regional dimension" of an innovation system has emerged as another aspect of an interactive model (Kline and Rosenberg 1986) that emphasizes the relationships of local companies with knowledge sources external to the firm—see also Asheim and Gertler (Ch. 11 in this volume). Such relationships—between firms and the science infrastructure, between producers and users of innovations at an interfirm level, between firms and the wider institutional environment—are strongly influenced by spatial proximity mechanisms that favor processes of polarization and cumulativeness (Lundvall 1988; von
p. 558 Hippel 1989). Furthermore, the ↳ employment of informal channels for knowledge diffusion (of so-called tacit or uncodified knowledge) provides another argument for the tendency of innovation to be geographically confined (Hägerstrand 1967; Lundvall 1992). The lack of existent capabilities in weaker regions hampers the potential for inter-regional technology diffusion (Fagerberg, Verspagen, and Caniëls 1997).

Some evidence on the extent of the locational concentration of the corporate capabilities for innovation that underpin competitiveness in Europe is set out in Table 20.5. It shows that except in the case of Germany in which there are four major regions that are each responsible for 13 per cent or more of the innovative capacity of the largest companies, of which the leading region accounts for 27 per cent, in all the other European economies the equivalent share of the biggest region is around 50 per cent or higher. This represents a quite remarkable geographical concentration of innovative capacity, far more than the extent of concentration of population or the total value of output. Given therefore that the interactions between the development of technological capabilities by firms and the supporting institutions found in their environment takes place mainly in such regionally bounded areas, this section begins by discussing the relationship between regional concentrations of activity or "industrial districts" and the competitiveness of individual firms (Malmberg, Sölvell, and Zander 1996; Porter and Sölvell 1998; Enright 1998; Scott 1998).

One particular aspect of regional systems that is underlined here is their interplay with the international dispersion of the creation of new technology and the new innovatory strategies of multinational corporations (MNCs), which have been associated with a restructuring of MNC technological operations at a
p. 559 subnational ↳ level. On the one hand, as seen above, there are general external economies and spillover effects which attract all kinds of economic activities in certain regions and determine, in the case of corporate integration, the localization of new research units. These centripetal forces strengthen the interborder intrafirm integration and the feedback of knowledge, expertise, and information which occurs within networks of affiliates. On the other hand, sector-specific localization economies intensify intraborder sectoral integration, implying local external networks between affiliates, indigenous firms and local non-market institutions. By tapping into local knowledge and expertise, foreign affiliates gain a competitive advantage which can not only be exploited locally but may also be transferred back to the

parent company, enhancing its global technological competence. Thus, Narula and Zanfei (Ch. 12 in this volume) refer to the recent shift away from asset-exploiting and towards asset-augmenting investments by MNCs, which is typically associated with a greater dispersion of innovative activity in the international network of an MNC. However, the nature of the relationship between MNC international innovation systems and local systems varies across regions (Cantwell and Iammarino 2000, 2001). This entails different types of regional strategy for technological competitiveness.

Table 20.5 The shares of patenting of the largest industrial firms attributable to research facilities located in the biggest single region of selected European countries, in 1969–95

Country/Region	Percentage
Belgium (Flanders-Brussels)	78.6
France (Île de France)	57.9
Germany (Nordrhein Westfalen)	27.0
Italy (Lombardia)	52.3
Netherlands (South Netherlands)	62.7
Sweden (Stockholm-Östra Mellansverige)	49.5
Switzerland (Basel)	57.5
UK (South East England)	46.9

Source: Cantwell and Iammarino (2001), and (for Germany) Cantwell, Iammarino, and Noonan (2001).

Evidence has now emerged that the choice of foreign location for technological development in support of what is done in the home base of the MNC depends upon whether host regions within countries are either major centers for innovation or not (termed "higher-order" or "lower-order" regions by Cantwell and Iammarino 2000). Whereas most regions are not major centers and tend to be highly specialized in their profile of technological development, and hence attract foreign-owned activity in the same narrow range of fields, in the major centers much of the locally sited innovation of foreign-ownedMNCs does not match very well the specific fields of local specialization, but is rather geared towards the development of general purpose technologies (GPTs) that are core to cross-industry innovation today (notably information and communication technologies, ICT) or in the past (notably mechanical technologies). The need to develop such GPTs is shared by the firms of all industries, and the knowledge spillovers between MNCs and local firms in this case may be inter-industry in character. Thus, ICT development in centres of excellence is not the prerequisite of firms of the ICT industries, but instead involves the efforts of the MNCs of other industries in these common locations.

Turning to competitiveness at the level of an individual firm, the determinants of cross-company growth summarized in Table 20.6 derive from a cross-sectional regression analysis of 143 of the world's largest firms between 1972 and 1982 (Cantwell and Sanna-Randaccio 1993). As has been remarked earlier, a key aspect of innovation and growth in the firm has to do with the largely industry-specific environment that firms have in common and which regulates their individual behavior and partially reflects their mutual interactions (Levin, Cohen, and Mowery 1985). Thus, the growth of demand and of technological opportunities in their own industry are key influences on corporate performance.

 Table 20.6 The statistically significant determinants of comparative growth among the world's largest industrial firms, 1972–82

Regressor	Sign of coefficient
Growth of own-industry demand	+
Growth of own-industry technological opportunities	+
Firm size	–
Firm-specific technological competitiveness	+
Degree of market power	+
Relative multinationality within own-industry	+
Increase in multinationality over period	+

Source: Cantwell and Sanna-Randaccio (1993).

It is curious that although the work of Penrose and Downie mentioned at the start of this chapter emphasized issues of the creation of firm-specific capabilities and intra-industry competitive rivalry, until quite recently even that minority of economists that did work on firm growth paid relatively little attention to these issues. However, now the notion of corporate competence has moved center stage in the strategic management literature (see Lam, Ch. 5 in this volume). Penrose had argued that the competitive advantages of a firm derive essentially from the cumulative and incremental learning experience of its management team, which experience differentiates it from other firms. The distinctiveness of the firm's accumulated experience and knowledge determines the set of opportunities for growth which it perceives ahead of its rivals when screening the external environment (the growth of demand and technological opportunities in its industry). Corporate technological competitiveness is the principal advantage of this kind associated with differentiated learning (Cantwell 1989; Teece, Pisano, and Shuen 1997). A higher technological capability lowers the unit costs and raises the demand curve of the firm at a given rate of growth, and it facilitates new entry into related product lines. A more technologically competent firm is able to utilize its existing experience to lower the costs of expanding its managerial and technical team in related areas. Technological competitiveness comes out as one of the most statistically significant influences upon firm growth of the variables listed in Table 20.6. In that large firm study, technological competitiveness was measured by the firm's share of patenting in its industry relative to its market share (of industry output), in terms of the relevant world industry.

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20.5 Conclusions

To return to where this chapter began, competitiveness derives from the creation of the locally differentiated capabilities needed to sustain growth in an internationally competitive selection environment. Such capabilities are created through innovation, and because capabilities are varied and differentiated, and since the creative learning processes for generating capabilities are open-ended and generally allow for multiple potential avenues to success, a range of different actors may improve their competitiveness together. Innovation is a positive sum game that consists of the efforts often of many to develop new fields of value creation, in which on average the complementarities or spillovers between innovators tend to outweigh negative feedback or substitution effects, even if there are generally at least some actors that lose ground or fail. The basic conclusion is that efforts to promote competitiveness through innovation can rarely be understood in isolation from what others are achieving at the same time. This applies whether we are speaking of countries, of national groups of firms in an industry, of subnational regions, or of individual companies. Indeed, it is worth emphasizing that the degree of interaction between innovators in search of competitiveness has tended to rise substantially historically, and has attained new heights in recent years.

Firms are less independent than they were, and they now all float in a much deeper sea of background knowledge, which Nelson (1992) refers to as the "public" element of technology. There are at least four aspects to this: intercompany knowledge flows have increased, there is a growing role for governments and other non-corporate institutions in knowledge development and transfer, the importance of science for technology has risen and diversified in its impact, and there has been a tendency towards more rapid codification and the formation and spreading of professional and scientific communities. We can now think of firms and the individuals aboard them like ships floating in a sea of public knowledge which connects them, or more accurately potentially public knowledge since the extent that they can draw upon it depends upon their own absorptive capacity and on their membership of the appropriate clubs (whether intercompany alliances or professional associations and the like). Over time, especially since 1945, firms have been designed to float deeper down in the water, but they still always leave a critical part comprising their own tacit capabilities above the surface, which does not sink down or fall into the general mass. Indeed, holding stronger capabilities above the surface is positively related to the depth to which one can reach below the surface, both for the absorptive capacity to extract complementary knowledge and for the extent to which one contributes oneself to the public knowledge pool. Universities and governments have increasingly contributed to the sea of public knowledge as well. Additionally, among firms that deliberately cooperate through technology-based alliances personnel can be exchanged so as to coordinate learning efforts.

p. 562 The sharing of knowledge between firms implies not just that technology must be developed through an interactive social and cultural evolution rather than through a biological evolutionary process involving competition between genetically independent entities, but also that followers and innovative adapters may stand to make greater gains than the original leaders in some new field of technological endeavor. For example, knowledge developed in one context may ultimately prove to have a bigger impact in another, which was not foreseen by the originator or even perhaps initially by the most innovatively successful recipients. Firms also now devote much greater effort to attempts to understand their own technological practice and that of others. Codification of knowledge is the outcome of a conscious effort, shifting back the dividing line between what is potentially public and what is tacit (Cohendet and Steinmueller 2000; Cowan, David, and Foray 2000). So firms that become especially adept at codification may find that this is a source of competitive advantage since they can then more readily draw on the public pool.

To engage in this intercompany interaction fruitfully, firms must maintain an adequate diversification of their in-house technological efforts, since the closer that knowledge is to the proprietary interests of a firm the more likely that it will only be shared in return for something else that is probably technologically complementary, which is what each firm needs to join the relevant corporate club (Cantwell and Barrera 1998). The entrepreneurial function has not been eliminated but it is more institutionally embedded in an ability to network and make new connections (see Powell and Grodal, Ch. 3 in this volume).

The interaction effects between innovators has been further compounded by the role of ICT as a means of combining fields of knowledge creation that were previously kept largely apart (or what Kodama 1992, terms technology fusion, and has led to the creation of new fields such as bioinformatics). ICT thus broadens the field for potential innovation by linking formerly separate areas of innovative activity. ICT potentially combines the variety of technological fields themselves and so increases the scope for wider innovation.

So, in the light of these recent changes in emphasis in the context for innovation and competitiveness, how can we reevaluate some of the earlier literature in the field that has been summarized here? Which lines of research have perhaps run out of steam for the time being, and which offer the most promising new avenues or opportunities for future research? The revival of the classical issues of competitiveness at a national level (Section 20.2) has been useful in that it represents a return of interest into the major questions of the wealth of nations, which are of primary importance from a social viewpoint. However, this new literature has also exposed the limitations of trying to tackle what are really issues of structural change at an aggregate level. It might perhaps be judged that we have gone about as far as we can for now with purely cross-country models. It may well be for this reason that the focus of the latest research has tended to shift to the industry
p. 563 and firm levels, allowing for (indeed now emphasizing more) the scope for technological ↳ interactions between firms and industries, so as not to lose sight of the wider context or the aggregate effects.

When recasting the analysis at an industry level (Section 20.3), we now know a good deal about historical shifts in patterns of industrial leadership between countries, about the role of education and skills in catching up economies, and how particular kinds of skills help to account for inter-industry discrepancies in innovative potential. Arguably we still know too little about the interaction between governments, non-business institutions, and firms (especially large firms) in the process of establishing competitiveness. In particular, we would like to know more about university–industry (science–technology) interaction over a wider range of countries, beyond the relatively clear picture that we have for the US (see Mowery and Sampat, Ch. 8 in this volume). The context here is what seems to be the growing significance of a local science base for the construction of corporate capabilities and hence competitiveness, including and perhaps especially in latecomer economies. Note that this newly emerging view reverses the "traditional" perspective that developing countries should concentrate on (organizational innovation in) lower-skill activities, and leave science to the largest most developed economies.

Coming to competitiveness at the firm or cluster level (Section 20.4), the latest research has also had a renewed focus on the role of intercompany interaction in knowledge creation and innovation, especially in subnational regional areas, and through alliances or cooperative agreements. Here we now know more of the details of the localized character of innovation, and of the steady growth in technology-based alliances as a means of facilititating competitiveness through knowledge exchange and spillovers. Work on firm size and innovation or growth seems to have rather run out of steam for now, at least insofar as it had regarded individual firms as quite independent entities. We need to know more about the specificities of knowledge flows between regions and between firms, of how and where technological knowledge is sourced by firms, and then how such knowledge is effectively combined in networks of interrelated innovation within and between firms. This is surely an exciting agenda for further research.

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