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Building Internationally Competitive Technology Regions: The Industrial-Location-Factors Approach and the Local-Technological-Milieux Approach

Kelvin W. Willoughby

In this paper I make the claim that academic business research on technological innovation and international competitiveness ought to move further in the direction of meso-level analysis, to complement the majority of research to date that has been conducted at either the micro level of analysis or the macro level of analysis. I survey meso-organizational literature from fields such as geography, urban studies and regional planning, and explore how theoretical contributions of those fields might be linked to recent insights from business research to produce strategies for building competitive technology regions. I conclude by outlining two alternative approaches, the "Local Technological Milieux" approach and the "Industrial Location Factors" approach. I suggest that high-technology industry development policies based on the Local Technological Milieux approach are more likely to be successful than policies based on the other approach.

1. THREE ACADEMIC TRADITIONS CONCERNED WITH TECHNOLOGICAL INNOVATION AND INTERNATIONAL COMPETITIVENESS

1.1. International Competitiveness and Technological Innovation

During the closing decades of the Twentieth Century scholars in business policy and strategic management (mostly from business schools) developed great interest in the theme of "competitiveness," especially international competitiveness. This was stimulated by the publication of Porter's extremely influential books on "competitive strategy" (1980) and "competitive advantage" (1985). Much of the interest in international competitiveness amongst business scholars was, and continues to be, nurtured by an awareness that technological innovation is a significant factor affecting the relative competitiveness of firms (e.g., Dosi 1984; Clark, Hayes & Lorenz, eds. 1985; Dermer, ed.1986; Link & Tassey 1987; Teece, ed. 1987; Furino, ed. 1988; Swann, ed. 1993; Utterback 1994; Leonard-Barton 1995). International competition in technological innovation and technology trade has thus become a centerpiece of research and policy making in business and public affairs at the beginning of the Twenty First Century (Dodgson 2000).

The primary theme in the first wave of literature on this subject was the simple observation that technological innovation ought to be recognized as a determinant of the economic performance of industrial of firms and industrial sectors (Hill & Utterback 1979; Pavitt 1980; Dosi 1984; Rothwell & Zegveld 1985; Freeman 1987; Teece 1987). Changing market conditions, increasing costs of industrial inputs, greater emphasis upon information flow as part of the economic process, more complex trading patterns, complex regulatory requirements, and sophisticated product-standard environments ~~to~~ name some of the key pressures facing contemporary businesses ~~were~~ seen to place a premium on an

organization's competence in adopting and managing new technology. Technology, furthermore, came to be seen not as something which emerged miraculously out of the "black box" of science and engineering, exogenous to the processes of the economy, but rather linked with the economic and managerial context (Rosenberg 1982). These themes continued to be prominent in the business literature of the 1990s (e.g., Dosi, Gianetti & Tininelli, eds. 1992; Silverberg & Soete, eds. 1994).

During the same period in which competitiveness emerged as a theme within business scholarship, rising international competition and interdependency in trade heightened the profile of technological innovation in economic policy, and firms came under increasing pressure to innovate in order to remain in business (Granstrand 1982; Rothwell & Zegveld 1983; Zysman & Tyson 1983; Krugman 1986; Furino 1988). As a consequence, the strategic management of technological innovation became an important component of corporate management and most national and provincial governments established some kind of ministry concerned with technology policy (Nelson 1993). This sustained attention on the role of technology in the economy has evoked some fascinating discussions on the relationship between public sector and private sector domains (Nelson 1992). The belief among economists, public policy-makers and business scholars that prowess in technological innovation is a key to economic health and competitive international trade intensified as the turn of the Century drew closer (Mansfield, 1995; Fagerberg, Verspagen & von Tunzelman 1994).

1.2. Micro Level Inquiry

Until recently most research conducted within business schools on the theme of international technological competitiveness has been conducted at the *micro* level of organizational inquiry (the firm), rather than at either the *macro* level (the nation) or the *meso* level (the locality or region).

During the last three decades business school scholars (e.g., Monger 1988; Nelson 1992b; Jelinek & Schoonhoven 1993; Dougherty & Hardy 1996; Lawless & Anderson 1996; Teece 1996; Powell & Dent-Micallef 1997; Koberg, Sarason & Rosse 1996; Sherman & Olsen 1996; Pitt & Clarke 1997; Rhyne, *et al*. 1997; Teece, Pisano & Shuen 1997) have been concerned, on the whole, with strategies for building the competitiveness of *firms*. Possible exceptions include the contributions of Van de Ven (1986), Weiss and Birnbaum (1989), Tornatzky and Fleischer (1990), and Willoughby (1993a). On the whole, however, business scholars have displayed little interest in explicitly incorporating *local* geographical factors in to research on competitiveness. Somewhat more interest has been exhibited in *national* factors affecting international competitiveness, rather than *local* factors, but the strongest emphasis has been on micro-level research. The same could also be said for many engineers–academic or otherwise–concerned with the relationships between technological innovation and commercial practice (see, e.g., Howard & Guile, eds. 1992).

1.3. Macro Level Inquiry

By the early 1990s, with the publication of books such as *The Competitive Advantage of Nations* (Porter 1990), *Technology and the Wealth of Nations* (Rosenberg, Landau & Mowery, eds. 1992), or *Country Competitiveness* (Kogut, ed. 1993), the organizational perspective of business scholars–normally anchored on the firm–began to open up to

deliberately incorporate a geographical dimension to discussions of competitiveness. This shift was also apparent in research emphasizing the public policy aspects of technology and competitiveness (Nelson 1992b & 1993). This geographical dimension was biased towards nations (the macro level), rather than regions and localities (the meso level). Ironically, while the case studies in Porter's *The Competitive Advantage of Nations* actually described industry clusters in localities and regions, the analysis and rhetoric of the book were couched in the language of whole countries.

The orthodox distinction in economics between micro-economics and macro-economics (which generally translates into a concern about the economics of firms and the economics of nations, respectively) has until recently been accompanied by only minor interest amongst academic economists in the economics of localities (such as neighbourhoods, cities, and urban regions). Economists working under the rubric of "regional science" have been exceptions within this tradition. On the whole, however, economists have devoted relatively little attention to "meso-economics" (the economic domain in-between micro-economics and macro-economics) and, in particular, to the geographical context of the city or locality.

This polarized way of looking at the economy has had an analogue in strategic management scholarship with the simple conceptual dyad of the "firm" and its "environment." Most introductory academic textbooks in strategic management (e.g., Thompson & Strickland 1995; Mintzberg & Quinn, 1996) incorporate this dyad as a central feature of the material which students are expected to master. While this dyad is not invalid, it obscures under the rubric of the amorphous "environment" many important local phenomena which are of significance to the building of competitiveness ~~of~~ firms and regional communities ~~but~~ which are lost in research about the business environment of nations. In other words, management scholarship has also tended to underplay the importance of the meso-organizational context of business relative to that of the micro-organizational and macro-organizational contexts.

1.4. Meso Level Inquiry

During the same period that academic interest in international technological competitiveness began to flourish, a number of local regions with economies based upon "high technology" industry complexes emerged, the most prominent of which (e.g., "Silicon Valley") were located in the United States. This stimulated efforts by national, regional and local governments throughout the world to emulate such complexes, in the hope of attaining regional economic development. Instruments devised for this purpose included technology parks, innovation centers, training programs, taxation supports, targeted research funding, regulatory streamlining, direct subsidies to firms, or special financial schemes to aid small high technology start-up businesses (Carter 1981; Blakely & Shapira 1984; Whittington 1985; Schmandt & Wilson 1987; Battelle Laboratories 1995; Mian 1996). These activities have been associated with a general interest amongst public policy makers and city planners in the theme of the international competitiveness of regions. New journals, such as *Economic Development Quarterly*, have emerged as organs for communication around this theme between scholars, practitioners and planners in the public sector, and industry leaders concerned with regional industrial renewal.

At the same time, another group of scholars and practitioners (e.g., Amin & Goddard 1986), mostly outside business schools, became increasingly concerned with strategies for improving the economies of *regions*. In other words, they were interested in understanding

the processes of technological innovation and competitiveness at the meso-level of organization. Although a number of geographers and planners associated with this group (see, van der Knaap & Wever, *et al.* 1987; Saxenian 1994; Blakely 1994; Castells & Hall 1994; Markusen 1994) appear to have been aware of research emanating from business schools, the literature, language, and professional cultures of the different groups—those concerned with technological innovation and firms and those concerned with technological innovation and regions—which emerged during the 1980s developed largely separately from each other.

A sizable body of scholarly literature was published during the 1980s around the subject of technological change and regional economic development (Malecki 1981; Thwaites & Oakey 1985; Amin & Goddard 1986), with much of the research concerned primarily with the spatial aspects of high technology. The reasons for the emergence of the debate over technological change and regional form, together with the concomitant policy experiments, were varied.

First, during the 1980s the phenomenon of "uneven development" received considerable scholarly and political attention. The uneven distribution of wealth has been debated widely since the classical work of Adam Smith and Karl Marx, but subsequent manifestations of this scholarly tradition, fed by contributions from a number of disciplines—including political economy, geography, city-and-regional planning, and sociology (e.g., Massey & Allen 1988; Marshall 1987; Swyngedouw 1992)—exhibited a strong spatial emphasis, stressing the theme that the economic disparity between regions and within regions exhibits structural features, changing in consonance with national and international macro-economic forces.

Second, uneven participation in state-of-the-art technology development and application came to be seen as an explanation of uneven economic development between and within regions (Armington, Harris & Odle 1979; Maillat 1982; Oakey 1984; Office of Technology Assessment 1984; Chapman & Humphrys 1987; Hamilton 1987; Sharp & Shearman 1987; Oakey, Rothwell & Cooper 1988; White, Braczyk, Ghobadian & Niebuhr 1988; Willoughby 1990). Some of the research dealing with this theme was based on particular technology-based industry sectors in particular places, such as micro-electronics in Britain (Morgan & Sayer 1988), but a body of literature also emerged aimed at producing concepts or policy principles which transcend particular geographical regions, fields of technology and industry sectors (Sweeney 1987; Storper & Walker 1989; Gonda, Sakauchi & Higgins, eds. 1994; Phillimore 1995).

Third, as a consequence of the above themes emerging within scholarly debate, cities—or urban regions—became recognized by some scholars as the locus for leading-edge technological development, with a number of prominent "international" cities or regions receiving the greatest attention: for example, the San Francisco Bay Area, the greater Los Angeles region, Cambridge in Massachusetts, Tokyo, or Cambridge and the M4 Corridor in Britain (Saxenian 1983; Hall & Markusen 1985; Segal Quince Wicksteed 1985; Boddy, Lovering & Bassett 1986; Tatsuno 1986; Hall, Breheny, McQuaid & Hart 1987; Scott 1988b; Sassen 1991). More recently, districts such as "Teheran Valley" in Seoul, Korea, or Munich, in Bavaria, have been added to the list.

Fourth, given the prominence of a relatively small number of international high technology regions, and their apparent interdependence, scholars sought to understand both the ways in which advanced technology industries affected regional form, and the ways in which regional form affected the prospects and form of local advanced technology industry

complexes (Brotchie, Newton, Hall & Nijkamp 1985; Brotchie, Hall & Newton 1987; Aydalot & Keeble 1988b; Tarr & Dupuy 1988). No generally accepted theory was distilled from these efforts, but a consensus does appear to have emerged that a shift from an industrial style of economy (with its emphasis on the flow of resources and goods, and the accumulation of tangible assets) to an advanced-industrial style of economy (with its emphasis on the flow of information and the accumulation of knowledge) will be accompanied by a shift away from the "19th century agro-industrial" city form (with its simple center-periphery land-use patterns) to something more complex and probably more decentralized (for a more recent treatment of this theme, see Brotchie, Batty, Blakely, Hall & Newton 1995).

The convergence during the 1980s of two fields of scholarly endeavor, technological innovation studies and regional studies, was mirrored in the national policy arena, with the emergence of deliberate efforts to create modern cities in which "high technology" and its associated social forms may flourish. Examples include the "technopolis" regions in Japan, the "multifunction polis" idea in Australia, or the "science city" in Taiwan (Glasmeier 1988a; Mandeville 1988; Masser 1989; Boekholt, Clark, Sowden, & Niehoff 1998; Cooke & Morgan 1994; Marceau 1994).

1.5. Interaction between the Three Academic Traditions

Some signs of convergence may be observed between the three groups of scholars; those conducting micro-level inquiry, those conducting macro-level inquiry, and those conducting meso-level inquiry. Strong moves in this direction have come from scholars in regional studies (e.g., Scott & Paul 1990; Sassen 1991; Segers 1992; Garnsey 1993; Saxenian 1990 & 1994; Noponen, Graham, & Markusen, eds. 1993; Blakely 1994; Kenney & Florida 1994; Markusen 1994; Brotchie, Batty, Blakely, Hall & Newton 1995; Lomi & Larsen 1996; Quinn & Dickson 1996; Rondinelli & Vastag 1997; Flynn & Forrant 1997). Until recently, in contrast, research conducted by scholars from business schools offered little to the literature on strategies by which *local* and *regional* communities may build international competitiveness. Nevertheless, signs of a possible shift in this situation have recently emerged.

Michael Porter (the most widely cited, and arguably the most influential, of researchers in strategic management), published an article entitled "New Strategies for Inner-City Economic Development" in the journal *Economic Development Quarterly* (Porter 1997), following an earlier article on the same subject published in the *Harvard Business Review* (Porter 1995). The *Harvard Business Review* has also recently published another contribution by Porter (1998) along these lines, entitled "Clusters and the New Economics of Competition." Notwithstanding these encouraging signals the two literatures—micro-level competitiveness studies and meso-level competitiveness studies—have continued to develop largely independently of each other. This applies to research on both the competitiveness of regions, in general, and research on the competitiveness of regions based on technology-related industrial innovation, in particular.

Most literature in the field of strategic management which explicitly addresses the subject matter of technological innovation (e.g., Burgelman and Rosenbloom 1993; Lawless & Gomez-Mejia 1994; Burgelman, Maidique & Wheelwright 1996; McGraith 1997; Aläng e, Jacobsson & Jarnehammer 1998) typically neglects to seriously consider spatial or locational factors in strategy and organization. However, some recent research on the role of

knowledge in strategy (e.g., Quinn 1992; Leonard-Barton 1995; Nonaka and Takeuchi 1995; Chen 1997; Fleck 1997; Helfat 1997) is beginning to step beyond the conceptual dichotomy of the firm and its environment as a theoretical frame of reference because of the importance of inter-organizational relationships for technological learning. Despite this movement, these studies tend to be anchored in the firm as the basic unit of analysis.

There has been growing emphasis recently in the strategy literature on the theme of inter-organizational relationships and the network form of organization in the domains of technology or research-and-development related business (e.g., Freeman & Barley 1989; Senker 1995; Harpaz and Meshoulam 1997; Millar, Demaid and Quintas 1997; Olk and Young 1997; Sakakibara 1997). This trend is further evidence of the importance of the meso-level of inquiry. Yet, while revealing the limitations of the orthodox focus on the firm-in-its-environment and showing signs of beginning to move beyond it, this literature remains anchored conceptually within a micro/macro frame of reference.

Some management scholars have begun to publish work which attempts to take an holistic view of technological innovation, linking together community, population and organization considerations (e.g., Wade 1995 & 1996; Drazin and Schoonhoven 1996; Henderson and Mitchell, *et al.* 1997). These recent initiatives, once again, move in the direction of affirming the importance of the meso-level of analysis for the strategic management of technology. They fall short, however, of formally embracing the idea. They also neglect to show interest in the spatial dimensions of technological strategy, and the local economic development implications of technological strategy.

Nevertheless, despite the "stickiness" of the three parallel academic traditions, there are signs of convergence between them, and there is an encouraging growth of interest in meso-level research on technological innovation and international competitiveness. In this paper I make the claim that academic business research on technological innovation and international competitiveness ought to move further in the direction of meso-level analysis, to complement the majority of research to date that has been conducted from within the micro/macro frame of reference. This task does not need to be conducted in an intellectual vacuum. There is a history of meso-level inquiry based in fields other than business and economics, upon which competitiveness research may draw. At the same time, meso-level scholarship on the development of cities and regions needs to be informed by insights generated by scholars of economics and business operating within the conventional micro/macro frame of reference.

In the latter part of this paper I will propose some strategy ideas for meso-level research in international technological competitiveness. Before doing so, however, it will be prudent to review some of the theoretical and empirical contributions on technology and regional economic development that have been produced by the group of scholars, introduced above, who have been engaged in meso-level inquiry during the last three decades.

2. CONTRIBUTIONS OF MESO-LEVEL SCHOLARSHIP TO RESEARCH ON TECHNOLOGICAL INNOVATION AND INTERNATIONAL COMPETITIVENESS

2.1. The Literature on Technology and Regional Industrial Form

The debate during the 1980s over factors determining the location of high technology industry emerged against the backdrop of traditional location theory for manufacturing

industry. This body of theory, "Weberian location theory" (following Weber 1929), points to transportation costs as the key determinant of optimal industrial location decisions, with firms weighing the relative transportation costs of access to raw materials, labor, and markets. Within this framework certain regions emerge as the most economic ones for certain industries because of their apparent capacity to minimize net transport costs. Once firms cluster in one of these optimal locations, agglomeration economies emerge, thereby reinforcing the existing economic advantages of the location for the particular industry in question. Variants of this type of theory have held sway until quite recently and have been reinforced by the observation that, both in Europe and in North America, the dominant trend in industrial location has appeared to be one of spatial concentration (Aydalot & Keeble 1988a: 1-2).

During the 1970s the capacity of traditional location theory to comprehensively explain industrial location patterns was increasingly questioned in the face of the decline of traditional industrial regions and the rise of new regions linked with emerging industrial forms. This was symbolized through reference to the rise of "sunbelt" cities based upon "sunrise" industries (Parry & Watkins 1977; Weinstein & Firestine 1978; Bluestone & Harrison 1982; Sawers & Tabb 1984). In contrast to the perceived general pattern of the previous half century, spatial dispersion emerged as the new emphasis in industrial geography. It appeared that throughout the industrialized world *dispersion* was superseding *concentration* as the key trend in industry location, and that this new trend also extended beyond the boundaries of the main industrialized countries into the Newly Industrialized Countries of the Pacific Rim (Keeble 1976; Castells 1986; Breheny & McQuaid 1987).

Technological change emerged as a variable intimately linked with these economic and industrial-geographic changes. The development of new technological products and processes (particularly in the area of information handling and communications) was seen to provide the means for overcoming traditional physical or economic constraints to the spread of industrial activity, both between cities and within cities. Some commentators have sought to explain this by minor modifications to traditional regional growth and industrial location theories (see, e.g., Rees 1986). Others have sought to introduce new concepts, such as that of the "informational city," whereby "space" is construed as the flow of information rather than as a geographical place (Castells 1984). In other words, the use of advanced technology is argued to enable decentralization of many industrial activities from the core to the periphery, while still maintaining the possibility of control and coordination from the center. Castells (1985: 12) summarizes the new perspective as follows:

> The most direct impact of high technology on the spatial structure concerns the emergence of a new space of production as a result of two fundamental processes: on one hand, high technology activities become the engine of new economic growth and play a major role in the rise and decline of regions and metropolitan areas, according to their suitability to the requirements of high tech production; on the other hand, the introduction of new technologies in all kinds of economic activities allows the transformation of their locational behavior, overcoming the need for spatial contiguity.

Thus, by the use of information technology a firm is able to concentrate functions of the organization while simultaneously dispersing the total organization by locating various parts of its activities in geographical locations best suited to each respective function or the organization's overall strategic goals. Some scholars have applied this insight to inter-

metropolitan location decisions (Gordon & Kimball 1986), and some to intra-metropolitan location decisions (Scott, 1983; Blakely & Fagan 1988).

Despite the purported "footlooseness" of high technology industries, such industries have in fact emerged in certain key geographical regions, the most famous of which is in Santa Clara County in California ("Silicon Valley"). Worldwide, the development of high technology regions has been rather uneven, with the result that much debate has emerged over just how feasible it is for more than a small number of such regions to thrive (Glasmeier, Hall & Markusen 1984).

The phenomenon of high technology regions has once again raised the theme of industrial *concentration* into prominence (Swyngedouw 1989; Scott 1988a). Given the evidence of some urban areas emerging as clear leaders in high technology, and given that early entry into such activity may provide a competitive economic edge to those places, some commentators have argued against the view that the wide uptake of high technology will diminish the importance of geographic location for industries. The idea that new technology is likely to entrench the dominance of a handful of principal world cities is now quite established in the literature (e.g., Moss 1987; Sassen 1991). Thus, along with the theme of concentration has come recognition that high technology regions tend to be located in urban areas.

Many attempts have now appeared to create profiles of high technology regions in the hope that they might form the basis of fruitful policy initiatives by city and regional governments (e.g., Herbig & Golden 1993). Saxenian (1989: 2) reports that the following features generally emerge from such studies as definitive parameters of high technology regions: (1) a high caliber research university to ensure a science-base and a supply of scientists and engineers; (2) an ample supply of venture capital to fund new firms; (3) public investment devoted to research and procurement of new technologies; (4) a quality of life able to attract and retain footloose highly-qualified professionals; (5) the absence of trade unions; (6) an industrial park to house start-up firms; and, (7) adequate infrastructure to ensure efficient transportation and communication linkages. Saxenian (1989: 2) wryly observes:

> The underlying message ~~th~~ough rarely stated ~~is~~ that once these prerequisites are assembled innovation and growth will follow. Like a soufflé which exceeds the size of the initial ingredients, a region endowed with the proper mix of institutional and economic resources will be the lucky recipient of rapid high tech growth.

Much of the literature on the nature of these high technology regions also appears to tacitly presume that there is such a thing as a *typical* high technology region; or, that with enough research, it might be possible to develop a single universal law of high technology development, capable of accounting for the evolution ~~or~~ non-existence, as the case may be in some places ~~of~~ high technology regions. One of the most ambitious large-scale statistical-empirical studies of the location of high technology industry in the United States, however, was unable to find evidence for such a general law, beyond the observation that the location of military spending appeared to be significant (Markusen, Hall & Glasmeier 1986).

2.2. Movements towards a General Theory of Technology and Regional Form

Notwithstanding the difficulty of the challenge of developing a general theory of technology and regional form some helpful contributions in this field have been published.

One line of research seeks to explain the geographic concentration and dispersion of high technology industry in a dynamic way by using product-profit cycle theory. Accordingly, during early stages of the cycle, high technology firms need to cluster in high technology regions to take advantage of services that they are unable to provide internally. This requirement declines in importance, however, as the industry or firm matures, and dispersion takes place to enable firms to take advantage of regions that offer lower costs (Markusen 1985).

Another line of research views high technology firms as involved in networks of transactions, with some firms highly disintegrated functionally and some highly integrated, reflecting the relative costs of internal and external transactions. Accordingly, high technology regional nodes ("technopoles") emerge as the spatial convergence of vertically disintegrated producers under conditions of uncertainty (Scott 1983; Scott 1988a; Scott & Angel 1987; Scott & Paul 1990).

Yet another line of research has concentrated on the access of firms to financial resources. Florida and Kenney (1988) have demonstrated through their research in the United States that the venture capital industry, which itself tends to agglomerate regionally for such reasons as the information intensive nature of the investment process, appears to play an important role in facilitating agglomeration in high technology industries.

Most of the recent research seeking general explanations of the spatial patterns of high technology industry has provided evidence for the importance of regional concentration rather than dispersion in advanced technology industries. It has also provided evidence, however, that individual industrial groups—whether based upon high technology or otherwise—exhibit distinctive characteristics, with likely distinctive spatial tendencies (Kenney & Florida 1994). The theme of the variability of the spatial concentration of advanced technology industries, both between regions and between specific high technology industries, has thus emerged. For example, Felsenstein and Shachar (1988) have shown that metropolitan location is important for both small and large high technology firms in Israel, but for different reasons in each case. Davelaar and Nijkamp (1989) have discovered that spatial factors are associated significantly with the performance of high technology firms in the Netherlands, but with important distinctions in the importance of highly urbanized locations between whether the focus is on process innovations or product innovations. Amrhein and Harrington (1988) have assembled evidence that technological heterogeneity in an industry can lead to variations in the locational inertia of firms. Glasmeier (1988a), through a series of case studies in Texas, has observed that the development of high technology industry agglomerations, and the nature of their economic spin-offs, vary according to the product type and the organizational structure of firms.

Despite these theoretical efforts no widely accepted general theory of technology and regional form has yet been embraced by scholars engaged in meso-level inquiry. By the end of the 1980s, however, some new themes emerged in the literature, signaling a shift away from interest in regional-form towards an interest in regional organization and activity. This shift, in effect, brought the work of scholars conducting meso-level research closer to the work of scholars from business schools engaged in micro-level research.

2.3. New Organizational and Institutional Themes in Regional Studies

The new themes in the meso-level literature emphasized organizational and institutional issues in industry, and adopted a dynamic approach to studying the connection between new technology and regional development. Although this latter perspective was not entirely new (e.g. Markusen 1985) it nevertheless signaled a departure from the orthodox "land use" and "environmental factors" approaches to regional industry development planning.

These new emphases appeared to have been stimulated by two developments. The first was a widespread concern about signs of decline of competitiveness of the hitherto pre-eminent high technology regions. The second was the emergence of the literature on flexible specialization in manufacturing (Piore & Sabel 1984; Sabel 1989; Capecchi 1990). The first development has led to a shift from the search for general explanations as to why existing geographical-technological patterns have come about towards inquiries into the kind of organizational, institutional, political or legal actions which might be pursued to ensure a healthy future for "our hitech" industry (read "Silicon Valley" or "Route 128" for United States, or "Cambridge" or "M4 Corridor" for Britain). In other words, discussion in the literature has been redirected from explaining the past to appreciating current dynamics of particular places as a guide to practical action. The second development has led to an interest in the role of inter-organizational and interpersonal relationships within and between industrial-technological-scientific complexes, and, as a consequence, the forms of governance appropriate to the new flexible forms of production.

Most scholars agree about the importance of flexible specialization, based upon the application of advanced information technologies, as a critical aspect of the dynamics of high technology regions. There is much disagreement, however, over the long-term implications this has for the competitiveness of existing high-technology complexes. There is also disagreement over the business or public sector strategies required to make them sustainable. At least four themes (which might even be considered as the focus for quasi schools of thought) have emerged as expressions of this disagreement.

The first theme, *structured flexibility*, was popularized by its leading protagonists, Richard Florida and Martin Kenney (1990). Their concept is modeled on a Japanese approach to industrial restructuring, and emphasizes the need for large corporations to provide certain system-governance functions throughout industrial complexes. Florida and Kenney argue that the highly flexible structure which has evolved in Silicon Valley and other American high technology regions contains a number of intrinsic externalities, such as separation of innovation and production and high labor turnover, which, they further argue, are not only undesirable in themselves but damaging to the international competitive position of the United States. The structured flexibility they advocate as a remedy involves a kind of quasi-integration of small firms under the umbrella of large corporations who would manage the network for efficiency, stability and strategic focus. In the contemporary Korean context, as a further example, structured flexibility could be attained by some kind of arms length governance of new venture companies and small-to-medium size enterprises under the umbrella of the Chaebol.

Florida and Kenney's critique of the Silicon Valley approach to technological innovation has been taken up by other, predominantly British, scholars (e.g., Hobday 1994) who point even more strongly to the role of large integrated corporations as necessary for the regional appropriation of the benefits of technological innovation.

The second theme, *collective order*, is associated most closely with its leading protagonist, Alan Scott (Scott 1992; Scott & Paul 1990), and is based upon a call for American industrial complexes to develop their own unique antidote to the problems and

instabilities of flexible specialization recognized by advocates of structured flexibility (with reference to the Japanese *keiretsu*). Rather than look to quasi-integration of complexes of small firms within hierarchies controlled by large corporations, Scott advocates a kind of institutional collectivism (not state ownership) amongst members of new production complexes. In his own words, guidance as to the likely forms which such collective order might take may be found in "novel social experiments involving interpenetrating structures of competition and cooperation and peculiar forms of collective action and governance." (Scott 1992: 220) Scott's approach requires cooperation of both private sector and public sector actors in areas such as technology development, labor training, business services, manufacturing, and land-use control.

The third theme, *regional networks* (or dynamic networks), is associated most prominently with the work of AnnaLee Saxenian (1989a, 1989b, 1990, 1994), although there are a number of well established schools of thought united by their interest in the concept of networks (see Willoughby 1993b). This approach is less pessimistic than the previous two about the ability of small firms in high-technology complexes to organize themselves to take advantage of the opportunities afforded by advanced technology in manufacturing, design and communication. Saxenian—whose ideas are based upon detailed multi-year case studies of the semiconductor and related industries in and around Santa Clara, California, and Cambridge, Massachusetts—points to the gains in efficiency of product development and manufacturing which networks of small organizations and individuals may accomplish through building relationships of mutual learning and trust through joint activity and cooperation. Her approach stresses the effectiveness of self-organization amongst small firms, while nevertheless recognizing both the need for trans-firm institutions and the important role of large corporations in local industrial networks.

The fourth theme, *innovative milieux*, at present amounts to no more than a minor theme in the English language literature, represented recently by the conceptual syntheses of Hall (1990), Maillat (1991), and Cooke and Morgan (1994). As summarized elegantly in Hall's 1990 essay, however, the theme has been much more strongly developed by several European scholars working outside the English idiom, especially Philippe Aydalot (1986) and Åke Andersson (1985) (see also Aydalot & Keeble 1988a & 1988b). The innovative milieux theme has much in common with the others (such as recognition of the local industrial complexes, based upon flexible specialization and vivified by network relationships) but, to a much greater degree than the others it places emphasis on intangibles such as attitudinal ambience and the complex interplay of cultural factors (such as intellectual, aesthetic and practical creativity, propensity for political open-ness, or technically progressive values) as substrata for technological innovation. Proponents of the innovative milieu idea take little interest in the search for single factor determinants of high technology growth and seek, instead, to understand the complex multi-dimensional processes by which knowledge is generated and renewed within an industrial context. Hall's masterly study of creativity and innovation in Western cities is a recent expression of this theme in the literature (Hall 1998).

Some scholars have combined insights from the dynamic-networks perspective and the innovative-milieux perspective in search of a more comprehensive approach to regional industry development policy. Examples may be found in publications by Bergman, Maier and Tödtling (1991), Camagni (1991), Marceau (1991, 1993), and Boekholt, Clark, Sowden and Niehoff (1998). A lucid essay by Marceau (1994), building on efforts by van Tulder and

others, makes a helpful distinction between "clusters," "chains," and "complexes" as three different approaches to public policy for regional industrial innovation.

By the mid-1990s explicit consideration of regional factors in international science and technology policy had become, while not routine, at least an important topic of discussion (Gonda, Sakauchi & Higgins 1994). Spillover effects in the regional economy from firm-based innovation received increasingly systematic analysis as a factor in regional economic development (Gonda 1994). While, in one sense, the attention now being placed on the regional economic dimensions of technological innovation is new, in another sense it is a return to an older yet neglected theme in economics typified by the work earlier this century of Marshall (1920). Willoughby's studies of regional clusters in the biotechnology industry in New York State (Willoughby 1993a 1997), Utah (Willoughby 1998) and California (Willoughby & Blakely 1989, 1990, 1991; Willoughby, Blakely & Nishikawa 1993), or high-technology "competence centers" in Germany (Grohs & Willoughby, et al. 1998), are an example of a contemporary manifestation of Marshallian economics, and illustrate how the Innovative Milieux theme may be systematically applied in empirical research.

2.4. Unresolved Theoretical Dyads in Meso-level Inquiry

What general conclusions may be drawn from the above meso-level theoretical forays? The literature on technology and regional development that appeared during the last two decades contains a number of ambiguities and unresolved tensions. These may be thought of as dyadic themes lying along five theoretical dimensions which will be labeled here as: geographical contiguity, structural uniformity, locational determinism, causal dynamism and analytical focus. These dyads, which are derived from my own theoretical synthesis of the literature, are portrayed in Table 1.

Within the first theoretical dimension, *geographical contiguity*, the literature contains arguments and evidence in favor of two contrasting themes. One is based on the idea that new technology encourages the dispersion of industry within regions and beyond regions. The other is based on the idea that technological change concentrates industrial activity into local geographical clusters. It is not always clear whether the subject of the debate is organizational control, manufacturing operations, intellectual capital, or human activity—and this ambiguity confounds the ongoing debate even further—but the tension between the two themes has garnered much attention.

Table 1. Tensions in the Meso-level Literature on Technology and Regional Development

THEORETICAL DIMENSION	*Theme*	*Counter-theme*
GEOGRAPHICAL CONTIGUITY	spatial dispersion	spatial concentration
STRUCTURAL UNIFORMITY	homogeneous regional form	heterogeneous regional form
LOCATIONAL DETERMINISM	single primary factor	multiple factors
CAUSAL DYNAMISM	direct linear causality	indirect non-linear causality
ANALYTICAL FOCUS	external-tangible environments	internal-intangible organization
POLICY ORIENTATION	*Orthodox*	*Progressive*
REGIONAL INDUSTRY DEVELOPMENT POLICY	relocation of foreign firms	local growth & entrepreneurship

Within the second theoretical dimension, *structural uniformity*, the tension in the literature is between the idea that there is one universal pattern to the regional form of technological change and the opposing idea that the regional form may vary between places and industrial contexts. For example, amongst those who embrace spatial dispersion as the natural concomitant of technological advance, disagreement may remain over the question of whether or not this relationship may be observed uniformly across national or cultural boundaries. Those who would argue in the affirmative would fit in the "homogeneous

regional form" category and those who would argue in the negative would fit in the "heterogeneous regional form" category.

The third theoretical dimension, that of *locational determinism*, deals with the question of whether or not it is appropriate to describe one particular factor as the primary determinant of the spatial behavior of high technology organizations or whether, instead, multiple locational factors ought to be seen as significant. For example, an argument to the effect that high technology firms relocate over time to low-cost areas fits within the "single primary factor" category because it sees the drive for cost reduction as a singularly important determinant of the location of industries as they mature. Conversely, those scholars who avoid the temptation to reduce industry locational dynamics to a simple universally-observable homogeneous process would probably fit into the "multiple factors" category.

The fourth theoretical dimension, that of *causal dynamism*, is concerned about the question of whether simple linear causality is even plausible as the mechanism by which "determining factors" influence the spatial behavior of organizations and other actors in technology-based industries. It also raises questions about whether or not it is even appropriate to speak of an identifiable logic of industry location related to locational factors. This fourth theoretical tension is rarely, if ever, discussed explicitly; but most writings in the field tend to presuppose a bias towards one of the two theoretical positions.

Those studies that seek to assemble a recipe of locational features conducive to high technology industry development tend to fit into the "direct linear causality" category, and are differentiated by whether they look to a "single primary factor" or to "multiple factors" in explaining locational determinism. In other words, they see external-tangible variations between regions as actually "causing" the locational patterns observed.

Research which abandons the "direct linear causality" presupposition is not common, but is emerging as part of the literature on innovative milieux. It is distinguished by the theme that, even if particular features of regions could be associated with high-technology industry locations, it would not follow that those features (or supposed "locational factors") actually "caused" the observed locational patterns.

To the extent that some kind of locational logic might be observed to operate, those commentators sympathetic to the "indirect non-linear causality" theme would look more to internal-intangible self-reinforcing processes of the local milieu, than to external-tangible aspects of regional environments, as explanations of spatial behavior. This brings us to the last theoretical dimension.

The fifth theoretical dimension, *analytical focus*, deals with contrasts in the basic subject matter towards which scholars direct their attention. Some studies are distinguished by their concern with external-tangible factors, such as availability of land, transport infrastructure, physical facilities, the local availability of raw materials or populations densities. Other studies are distinguished by their concern with such internal-intangible factors as business culture, institutional arrangements, communication patterns, knowledge profiles, or human capabilities.

It is not easy to attach particular scholars in a rigid manner to only one of the themes from Table 1, as some appear over time to have subtly shifted their thematic stance and others may even exhibit both theme and counter-theme during the same period. It is perhaps also inappropriate even to speak of schools of thought based upon these themes. Rather, the themes run throughout the literature providing the fuel that has kept much of the debate

going. The debate and research of the 1990s onwards is framed by the foregoing theoretical polemics as depicted in Table 1.

It is not yet clear how the theoretical issues raised during the 1980s will, if ever, be resolved. Nevertheless, the new themes that emerged in the literature during the1990s represent a gradual shift in orientation from the top left corner of Table 1 towards the bottom right corner. In other words, along with the recognition that heterogeneity of regional form may occur simultaneously with the spatial concentration of industry into local clusters, has come a recognition by a minority of observers that the "locational factors" approach to the industrial geography of high technology, with its focus on a narrow range of determining factors and its simplistic notion of system causality, may have been misdirected. Rather than seeking to identify "what causes firms to locate" in a particular place, recent scholarship has come to focus more on the dynamics of the local industrial complexes and on the invisible factors in local socio-organizational networks that affect the vibrancy of local industrial-technological behavior(e.g., Grahber, ed. 1993).

The underlying spirit of the new literature may be encapsulated as follows: *The Holy Grail of the "ultimate causal factor" has been superseded by the Round Table of the "multi-dimensional evolutionary process."*

The shift in theoretical perspective that has taken place during the last two decades has an analogue in policy-making for regional development. The gradual shift in theory from the themes on the left side of Table 1 to the counter-themes on the right side of the Table has been matched by a shift from the "orthodox" policy orientation in Table 1 to the "progressive" policy orientation also indicated in the Table. The progressive policy making orientation for regional economic development downplays attempts by regional authorities to induce firms from elsewhere to relocate to the local region. Instead, it places attention on facilitating endogenous local entrepreneurship and business growth. Recognizing the importance of institutions and invisible social and organizational factors in local regions leads naturally to an emphasis on local entrepreneurship. Firms created from within the local region tend to be embedded within local social and business networks, and hence tend to be more "loyal" to the region than relocated firms with social and business networks grounded in communities located elsewhere. The complexity and multidimensionality of local technological industry complexes, as emphasized by those embracing the counter-themes in Table 1, militates against success in attracting firms to relocate from elsewhere.

This shift from an emphasis on industrial relocation to an emphasis on local venture creation is not universal. Many (if not most) communities and policy makers retain the orthodox "industrial relocation" perspective. Nevertheless, the turn of century has brought with it widespread experimentation with endogenous approaches to technology-related local economic development.

3. STRATEGIES FOR INTERNATIONAL TECHNOLOGICAL COMPETITIVENESS

The balance of this paper will be devoted to *strategy* concepts. I will outline two contrasting approaches to building internationally competitive technology regions, drawing upon the raw material of the meso-level theoretical literature presented above.

The two contrasting policy orientations included in Table 1 may be seen as particular expressions of two general approaches to technological industry development that I will now describe. One of the two approaches speaks to the concerns of the most recent literature

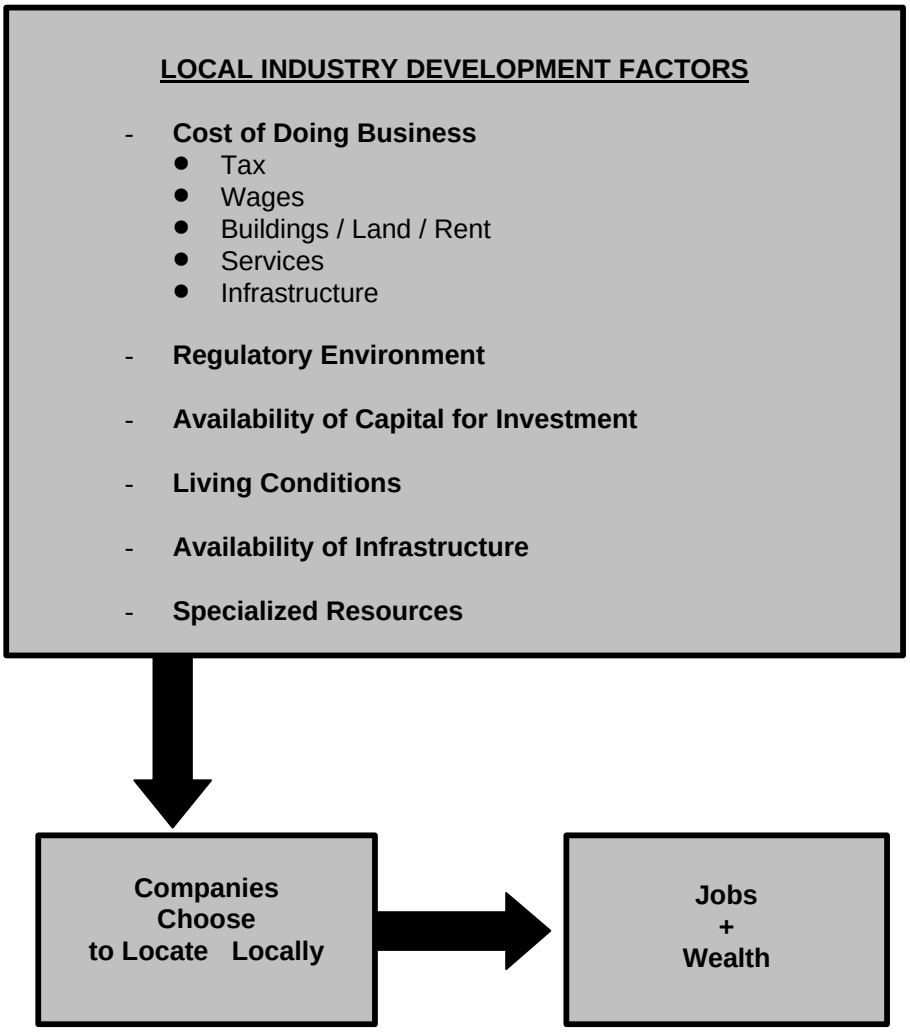
in both the geography-based research tradition and the firm-based research tradition. I call this approach, which is somewhat unorthodox, the *"Local Technological Milieux"* approach. I contrast it with the more orthodox *"Industrial Location Factors"* approach, which corresponds to the older literature, and which I will describe first.

The ideas I describe below are derived from my analysis of the meso-level literature on technology and regional development. They have been additionally inspired and guided by my direct observations through professional activity and research, over a period of more than a decade, in high technology industry clusters in a variety of locations internationally (Willoughby 1993a, 1997, 1998; Willoughby & Blakely 1989, 1990, 1991; Grohs & Willoughby, *et al.* 1998).

3.1. The "Industrial Location Factors" Approach

The *Industrial Location Factors* approach is a strategy for building up local technology-based industry by seeking to attract "desirable" (high technology) firms from elsewhere in the world to relocate to "our place" through making resources (tangible resources, typically) in the local environment more accessible and less expensive. This strategy will be recognized by most informed readers as an orthodox approach followed by the vast majority of economic development agencies and industry development organizations, internationally, at least until relatively recently. There is probably no formal, theoretical, advocacy of this approach in the literature; rather, it is the dominant guiding principle that is tacitly assumed by the proponents of countless economic development programs. The Industrial Location Factors approach is illustrated in Figure 1.

Figure 1. "Industrial Location factors" approach to industry development



Typically, local authorities or industry-promoters adopting this strategy will seek to put in place such "attractive" resources as: subsidized land, roads/railways, waste-disposal, energy-supply, water-supply, or other kinds of physical facilities; subsidized training facilities (e.g., technical schools) near the site; supplies of cheap labor (through industrial-relations policies); taxation exemptions; and relief from regulations (such as environmental regulations or labor/employment regulations). The ultimate aim is to make it easier for firms to reduce their cost of doing business locally, by reducing their cost of access to

resources. The Industrial Location Factors approach also assumes that a policy-action (e.g., a tax break, or the provision of subsidized space in a technology park) will bring about the desired result (improved locally-based global technological competitiveness) in a simple, direct cause-and-effect manner. Critical reviews of programs based upon this approach may be found in Bridges (1965), Rubin and Zorn (1985), and Blair and Premus (1987).

3.2. The "Local Technological Milieux" Approach

In contrast, the *Local Technological Milieux* approach is a strategy for building up local technology-based industry by facilitating the emergence of new technology-based entrepreneurial business activity from within the existing community (rather than by attracting firms to relocate from elsewhere). Instead of emphasizing making business resources accessible and affordable for firms, this approach seeks to nurture new entrepreneurial activity from networks of relationships between people and organizations already grounded in the local community. In other words, it seeks to indirectly generate a local technological milieu.

Proponents of the approach focus on intangible factors in the local milieu. The Local Technological Milieux concept draws heavily on the innovative milieux concept; but it is focused on a particular technological-scientific domain, and stresses that technological innovation and technology-based industry development tend to grow, not so much from the input of resources from the local environment and the combination of factors from the local environment, but as a *self-renewing process which has no single cause other than the process by which it sustains itself.*

The Local Technological Milieux approach is illustrated in Figure 2. The concept of the Local Technological Milieu (or "Milieux" in the plural), upon which it is based, is outlined in Table 2.

Figure 2. Local Technological Milieux and Competitive Industry Development

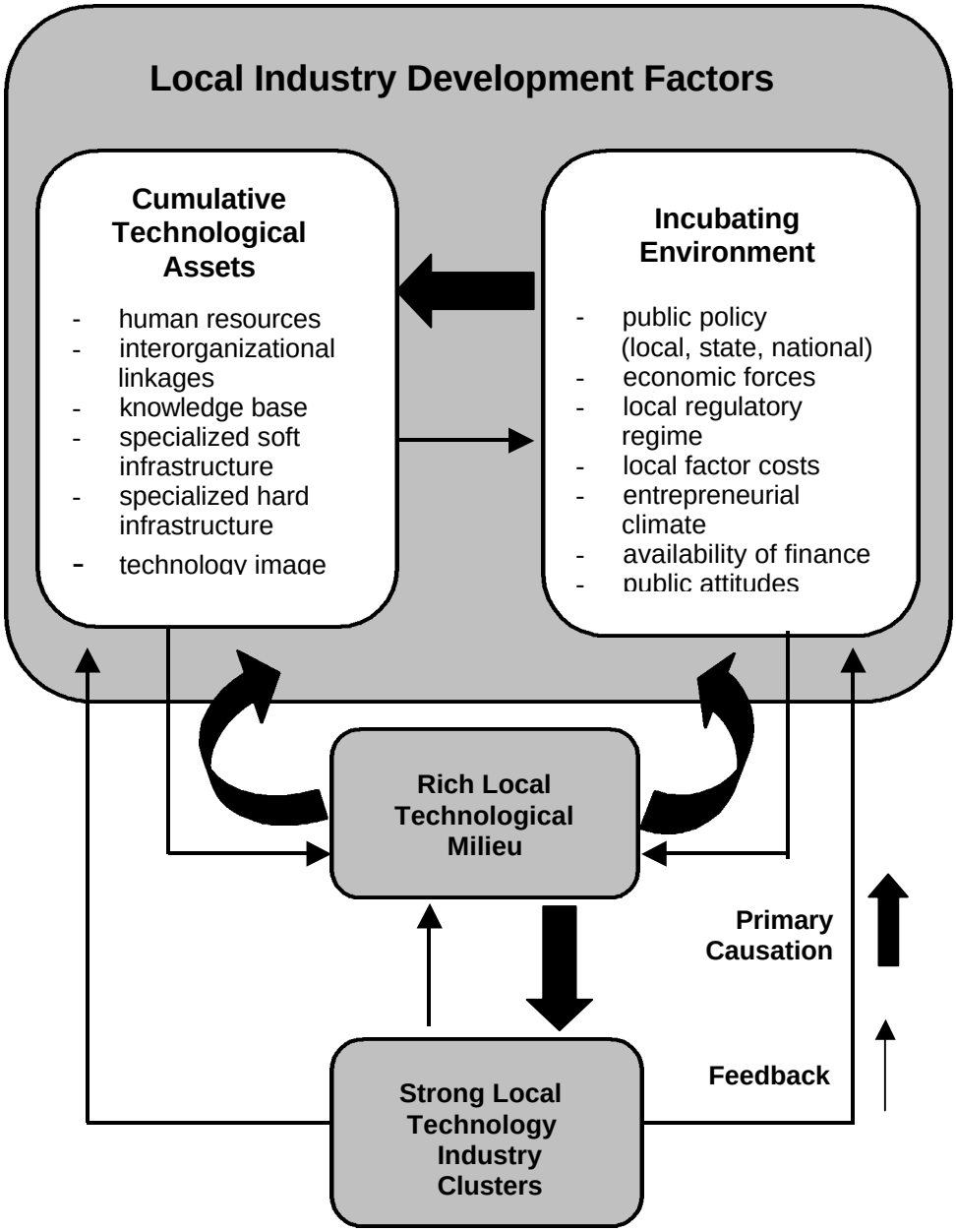


Table 2

The "Local Technological Milieux" Concept

Definition of a Milieu

- A local technological milieu is a coherent space (expressed along socio-cultural, organizational-institutional, and knowledge-informational dimensions) within an environment, centered around a particular domain of technology-practice

[Note: the word "milieu" is not just another word for "environment"]

Characteristics of a Milieu

- The population of "member" organizations and people within a locality needs to rise above a threshold level for a local milieu to emerge
- The activities of participant organizations are specialized (technologically)
- The specialization and character of organizations in the milieu relates to the history and spirit of the place (i.e., milieu peculiarity is rooted in locational peculiarity)
- The core domain of technology-practice in the milieu (probably embodied in an industry) needs to be accompanied by an array of complementary domains of technology-practice (probably embodied in complementary industries) also present and active within the milieu (or closely connected milieux)
- A unifying culture and a unifying system of symbols may be identified with the milieu
- Specialized institutions arise within the milieu to support the emerging technology-practice and organizations within which it is embedded
- There are rich patterns of communication and collaboration between organizations and/or individuals within the milieu, between milieu, and between the milieu and its environment
- The milieu is dynamic and resilient
- The milieu has an "image" with which its members identify and which outsiders may also recognize
- The milieu produces a distinctive body of knowledge which may not necessarily be successfully transferred with integrity outside the milieu
- The technological milieu is embedded within a social milieu
- The local technological milieu is probably vivified through symbiotic relationships with

other local technological milieux; they may function together as a structured complex of
micro-milieux within a macro-milieux

This approach is consonant with the five "counter themes" and the progressive policy orientation listed on the right hand side of Table 1. The Industrial Location Factors approach, in contrast, is consonant with the five "themes" and the orthodox policy orientation listed on the left hand side of Table 1.

For the Local Technological Milieux concept to be comprehended properly it is important to recognize the conceptual distinction between "milieu" and "environment." While the notion of the *local milieu* does relate closely to the notion of the *local environment* in which an organization (such as a firm) operates, the two are conceptually distinct. In the words of Maillat (1991: 268-269), who appears to have understood the significance of this distinction more than most scholars:

> The milieu may be defined as a coherent area organized around its physical structures (territorial production system, regional labor market, regional scientific institutes) and around its non-material structures (culture and technical culture, and representation system, ~~the~~ collective way of perceiving events and responding to them). … The milieu is thus an area integrated with elements, in particular resources; the environment, on the other hand, is a disparate complex from which elements have to be derived which are likely to enrich the milieu.

The milieu, in other words, to the extent that it emerges at all, emerges within an environment, but cannot be explained deterministically by analysis of factors in that environment.

3.3. Comparing the Two Approaches

The two approaches may also be compared using metaphors from the ancient Arthurian myth (associated with King Arthur, his kingdom, his knights and their quest). Images of the Holy Grail and the Round Table, from this myth, may be used to evoke the notion of a critical choice between two strategies in business and technology: one (evoked by the Grail image) is centered on the search for a single, reliable determinant (one-dimensional turn-key solution) to the challenge of how to build global technological competitiveness; the other (evoked by the Round Table image) is centered on a complex quasi-reliable approach (multi-dimensional process) for working towards global technological competitiveness. There is more than one possible process for pursuing international competitiveness.

With a little literary license we may look to the Round Table as a metaphor for the Local Technological Milieux approach to building strategies for global technological competitiveness within localities and regions. This approach emphasizes that technological competitiveness is grounded in the dynamics of real localities and communities, and that it is gradually nurtured through a multi-dimensional evolutionary process rather than created quickly from a simple cause or action.

Once again, with a little literary license, we may look to the Holy Grail as a metaphor for the Industrial Location Factors perspective. The Industrial Location Factors perspective leads to a strategy for building up local technology-based industry by seeking to attract "desirable" (high technology) firms to relocate to "our place" from elsewhere in the world through making tangible resources in the local environment more accessible and less expensive. The general idea is that if you could just get the "right factors" in place the firms will relocate from elsewhere … "build it and they will come!"

In contrast, the Local Technological Milieux perspective would lead to a strategy for building up local technology-based industry by facilitating the emergence of new technology-based business activity from within the existing community (rather than by attracting firms to relocate from elsewhere); the growth of such activity would be nurtured from within networks of relationships between people and organizations which are already grounded in the local community. Such a strategy would focus on intangible factors in the local environment such as: people and their knowledge; the culture and history of the place; the richness and complexity of symbolic experience and communication between people and organizations; and the vigor and diversity of pertinent local institutions (such as industry associations).

Strategies based upon the Local Technological Milieux perspective do not assume that a desired result may be simply brought about ("caused") as a result of a specific policy action (e.g., establishing a technology park, or setting up a state-subsidized venture-capital program). The Local Technological Milieux approach points to an indirect, multi-faceted, non-linear, and un-predictable relationship between means and ends. The Local Technological Milieux approach nurtures the development of complexes of intangible factors which, through synergy, facilitate communication locally and globally by significant actors within the local milieu, and between them and those in other milieux.

While the two perspectives contrast strongly with each other, policy initiatives consistent with one may be compatible with policy initiatives consistent with the other. For example, while a technology park or research park might typically be employed as a policy tool by those following the Industrial Location Factors approach, it could also be employed effectively by those following the Local Technological Milieux approach, but in the latter case it would be managed in such a way as to facilitate complex communication activity by its tenants, rather than primarily to reduce the cost and difficulty of access by its tenants to resources (including those of local universities).

The primary feature of the Local Technological Milieux approach as portrayed in Figure 2 is that the regional industrial process associated with technology involve three main dimensions: local technology industry clusters, local technology milieux, and regional development factors (which include cumulative technological assets and the incubating environment).

The approach also embodies the notion that local technology industry clusters do not emerge in isolation, but rather within local (or regional) technology milieux. There are two levels at which the concept of "region" is relevant: the *mega-region* (e.g., a state or province) and the *local-region* (e.g., a city).

In principle there are probably forces acting between each one of the elements in the system and all of the others, and this could be represented by a complex web of two-way arrows linking each one of them. Figure 2, however, seeks to discriminate between those forces which are dynamic variables in the industry, and therefore of special significance for the purposes of policy making, and those which, while formally identifiable, are not of great

importance for policy makers. The "dynamic" forces included in the model are symbolized by the thick arrows, and represent the processes which most directly lead to the development of local technology industry clusters. The thin arrows represent the important feedback processes which operate throughout the system.

In addition to the small group of scholars mentioned earlier who write about "innovative milieux" or "creative milieux" there is one emerging school of thought, associated with the Santa Fe Institute, in New Mexico, which has generated research consonant with the Local Technological Milieux theme just adumbrated. This group of scholars, drawn from fields as wide apart as physics, biology, mathematics and economics, are united by their interest in the sciences of "complexity." In particular the group (see, Anderson, Arrow and Pines, eds. 1988; Arthur, Ermoliev and Kaniovski 1987; Arthur 1988, 1989a, 1989b, 1990) has elaborated the concept of evolving, path-dependent, complex self-managing systems with positive feed-back loops (in contrast to the more orthodox approaches in economics which theorize on the assumption of simple systems which come to equilibrium, involving negative feed-back loops.) The idea of the complex evolving system (which, incidentally, is also found in the path-breaking work of economist Richard Nelson and Sidney Winter (1982)) appears close to that of the Local Technological Milieu.

3.4. Advantages of the *Local Technological Milieux* Approach over the *Industrial Location Factors* Approach as a Theoretical Framework

The Local Technological Milieux approach has a number of advantages over the Industrial Location Factors approach in explaining the development of high technology industry complexes during the second half of the Twentieth Century.

There are a number of cities that should have become dominant international high technology industry centers during the last several decades, if the Industrial Location Factors approach was an adequate explanatory framework, but which did not in fact rise to such a position. Chicago and New York City are the obvious examples. Both of these cities were major metropolitan regions with all of the necessary "ingredients" mid-way through the Twentieth Century. Both were surpassed by lesser cities, such as the San Francisco Bay area or the Cambridge/Boston metropolitan area that, mid-century, were weaker in most of the factors emphasized by the Industrial Location Factors approach. These "upstart" cities were the homes to certain processes and qualities not emphasized by the Industrial Location Factors approach.

Conversely, some of the cities that have become the home for dominant high technology industry complexes by the beginning of the Twenty First Century have some important attributes that, according to the Industrial Location Factors approach, should have prevented them from rising to their current internationally competitive positions. Tokyo, the San Francisco Bay area, and Munich, for example, are all very expensive places yet that fact has not prevented them from thriving. Indeed, even as the cost of doing business in such cities grows higher relative to other cities their competitive advantage appears to have increased rather than decreased. These cities have other factors working in their favor, factors emphasized more prominently in the Local Technological Milieux approach than in the Industrial Location Factors approach.

The Local Technological Milieux approach explicitly incorporates the "invisible" factors—information, knowledge, culture, communication, to name a few—that are central to the conduct of modern technology-and-science intensive business activities. Given that the

high-technology regions are, by definition, technology-intensive and knowledge-intensive, a theoretical approach that more fully embraces the dimensions of a knowledge-intensive society is more likely to be fruitful than one based more heavily on the older "industrial age" commonplaces.

The Local Technological Milieux approach is also theoretically more attractive than the Industrial Location Factors approach because of the intellectual compatibility it exhibits (as part of the meso-level of organizational analysis) with the recent theoretical trends of scholarship emanating from business schools (based in the micro/macro frame of reference). The themes of knowledge management, organizational networks, social embeddedness, and dynamic capabilities, which are now embraced in business schools, link naturally to complementary themes embraced by the more progressive scholars engaged in meso-level inquiry.

Finally, the strengths of the Local Technological Milieux approach just described mean that insights gained from meso-level research on high technology industry may be applied fruitfully for decision-making at the micro-level of organization (see, e.g., Willoughby 1999). In other words, the approach may be useful to managers of high technology firms, not just to political and industry leaders concerned with economic development in high technology regions.

Having just described some of the theoretical and practical advantages of the Local Technological Milieux approach it is nevertheless appropriate to ask, "What empirical evidence is there that such an approach would be feasible in practice, and what empirical evidence is there for the theoretical superiority of the Local Technological Milieux approach over the Industrial Location Factors approach?" I propose, on the basis of the ideas sketched in the preceding pages, that an empirical research program be developed to address these questions. These ideas may be investigated in parallel at the micro, meso and macro levels of analysis. I will now outline some suggestions for how such a program of research might be pursued.

4. SUGGESTIONS FOR AN AGENDA FOR EMPIRICAL RESEARCH

The power of the ideas outlined in the preceding pages may be tested through empirical research in two ways.

First, the concept of the Local Technological Milieu may be tested by its power to facilitate *positive* analysis. A geographically-oriented or regional approach to research is a natural corollary of these ideas. The success of such an approach in illuminating the structure, position, distinctive characteristics, and economic significance of regional technology-based industries may be interpreted as a demonstration of the power and validity of the concept.

Second, the concept of the Local Technological Milieu may also be tested by its power to facilitate *normative* analysis. The ability of research based on such a concept to produce performance-oriented strategy principles, for either local/regional policy makers or the managers of firms, will be taken as a reflection of the normative power of the concept.

Table 3 summarizes the respective *locational behavior determinants* and *inter-organizational behavior features* we would expect to associate with technology-based organizations if each perspective ~~–~~the Local Technological Milieux approach and the Industrial Location Factors approach ~~–~~was valid. If successful firms tended to be associated

with the determinants and features on the left hand side of Table 3 we would conclude that the Industrial Location Factors perspective held greater explanatory and normative power; whereas if successful firms tended to be associated with the determinants and features on the right hand side of Table 3 we would conclude that the Local Technological Milieux perspective held greater explanatory and normative power.

Table 3.

Indicators of "Industrial Locational Factors" Approach	***Indicators of "Local Technological Milieux" Approach***
LOCATIONAL BEHAVIOR	
Determinants:	**Determinants:**
- Regulatory Regime	- People
- Cost of Doing Business	- Knowledge
- Access to Resources	- Institutions
INTER-ORGANIZATIONAL BEHAVIOR	
Features:	**Features:**
- Isolationist	- Inter-connected
- Secretive	- Open-with-knowledge
- Self-sufficient	- Inter-dependent
- Non-communicative	- Communicative
- Protectionist with Assets	- Cooperative with Assets

The research directions suggested above would be conducted with and eye to applying general ideas derived from the field of strategic management (as practiced by scholars from business schools) to the new context of local-cum-regional technology-based industry

development. The suggested approach would also involve creatively employing the analysis of *firms* as a tool to aid the analysis of *regional economies*. While this may seem to be somewhat unorthodox for strategic management research, we may take heed from Markusen (1994), who has written about the challenges of "studying regions by studying firms." The recent studies of others, such as Saxenian (1994), Blakely (1994) or Castells & Hall (1994), whose studies have affirmed the importance of the meso-organizational context of technological change (without actually making the concept explicit), also point to the potential power of the approach suggested here. The research challenge of the Local Technological Milieux approach brings meso-organizational analysis into the limelight of business and economics research alongside micro-organizational and macro-organizational analysis.

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Kelvin W. Willoughby. College of Engineering and Applied Sciences, State University of New York at Stony Brook, 100 Engineering Building, Stony Brook NY 11794-2200 USA. Tel:+1(631) 632-7192. Fax: +1 (631) 632-8205. E-mail: kwilloughby@notes.cc.sunysb.edu