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Small-industry clusters, accumulation of technological capabilities, and development: A conceptual framework

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ABSTRACT

Research on clusters of small and medium industrial enterprises in developing countries is increasingly focused on the determinants of long-run competitiveness. This paper develops a conceptual framework to analyse this issue. It builds upon, and links up, research about collective efficiency in small-industry clusters and literature about acquisition of technological capability in development. It identifies the different agglomeration advantages that commonly occur in industrial clusters and then examines the ways in which these advantages may boost knowledge accumulation within firms in a cluster. Theoretical insights from literature about clustering, agglomeration advantages and technological development from developing and advanced economies are combined in order to make the assessment.

Keywords: Industrial clusters; Technological capabilities; Small and medium enterprise development; Technological learning; Knowledge spillovers; Regional competitiveness

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1. INTRODUCTION

Until recently, small and medium enterprises (SME) in developing countries were mainly local affairs: using local inputs, run by members of local communities, making goods which satisfied the needs of local people, and boosting local incomes, employment and entrepreneurship. In barely one decade, this situation appears to have changed. Widespread economic deregulation and liberalisation, coupled with rapid reduction in transportation costs and advances in ICT, are spurring the emergence of large international production and trading networks which are reaching out into poor and remote countries. Many hitherto local SME in these countries are beginning to be exposed to global competition, either through direct integration into large commodity chains, or, indirectly, through penetration of their traditional home markets.

Researchers have begun to throw light on how SME are responding to these processes, and to work out ways of confronting the new competitive challenges and benefiting from newly emerging market opportunities. One salient finding is that the competitiveness of SME could be boosted when they are part of regional agglomerations of firms engaged in similar and complementary activities – commonly denoted as ‘clusters’. Inspired by studies about the emergence of highly successful clusters in advanced countries, such as Silicon Valley, Emilia Romana in Italy, and Baden-Wuerttemberg in southern Germany (for example, Piore and Sabel, 1984; Best, 1990; Pyke and Sengenberger, 1992), the idea has gained ground that SME clusters in less-developed nations, too, might be able to boost regional development by creating possibilities for accumulating capital and skills through ‘collective efficiency’ (Schmitz, 1995; Schmitz and Nadvi, 1999).

So far, research has concentrated on the economic benefits to which clusters may give rise, while the technological factors underpinning these benefits have been given rather

cursory treatment. Yet, in order to meet global competition, SME do require capabilities to continually absorb, reproduce, adapt and improve new technologies related to products, production processes and production organisation – technological capabilities, in short. The great majority of SME currently do not have these capabilities. Therefore, if clusters are to be effective vehicles for improving SME competitiveness, they must yield more than static cost-savings due to local availability of inputs, scale advantages due to large local demand, and so on. Above all, they should trigger dynamic economies by stimulating intra-firm accumulation of technological knowledge and skills.

Little work has been done to assess the capacity of developing-country clusters to play the latter role. Only one study has seriously begun to explore their technological dynamics (Bell and Albu, 1999); however, while it yielded useful insights, much remains to be done. Most importantly, there is still no consistent conceptual framework grounded in received economic theory with which one can study the relationship between knowledge accumulation and the spatial proximity of participating actors. Such a framework is needed for empirical work, and for the design of effective policy interventions aimed at stimulating economic growth in regions.

The aim of this paper is to develop such a framework. We use received economic theories as conceptual tools to identify and classify the main mechanisms through which industrial agglomerations can help to trigger or stimulate accumulation of firm-level capabilities of different kinds, and spell out the reasons why proximity between the learners offers advantages in this regard.

The focus of this paper is thus on *how* technological learning occurs in clusters as and when the phenomenon is actually underway. It does not explore *why* certain regions are learning-rich while others stagnate. The latter is a much more ambitious question, requiring an exploration of governance structures in production chains, cultural and social ties, and

functioning of institutional support, to name just a few pertinent issues. These issues cannot be addressed within the limited scope of this paper.

In Section 2 we highlight relevant insights from the collective efficiency (CE) and technological capability (TC) literatures, and their main limitations from our point of view. The line of argument linking clustering, technological learning and development is developed in sections 3 to 5. In section 3, we first establish the different advantages to which clustering may give rise. In section 4, we spell out the effects of these advantages on the technological improvement efforts of clustered firms. In section 5, we outline the likely implications of these effects on the accumulation of firm-level capabilities and economic performance. The points in sections 4 and 5 are illustrated with evidence from existing empirical work, to the extent possible. Section 6 presents the conclusions and offers an agenda for further work.

2. POINTS OF DEPARTURE

The two strands of literature that form the main points of departure for this paper have evolved separately, and they show little conceptual and empirical overlap.¹

In the collective efficiency (CE) literature,² clustering has been placed centre-stage, but its implications for technological progress have remained rather peripheral. This has to do with the fact that the main focus of the analysis has been on the regional ('meso') level, while firm-level dynamics have received less attention. Studies that shed light on inter-actor relations have formed the main sources of inspiration, including transaction cost theory, socio-geographical studies dealing with regional dynamics, sociological approaches, and most recently Gary Gereffi's work on global commodity chains (Humphrey and Schmitz, 2000). Most CE studies address some aspects of 'upgrading', but this concept is not rooted in an analytical framework in which firm-level technological change takes central stage.³

The durability of an SME cluster's competitiveness depends on the technological capabilities of its firms. Therefore, the main problem with the CE literature is that the competitive prospects of clusters cannot be assessed thoroughly as long as the functioning of firms remains largely a black box (Figure 1).

[INSERT FIGURE 1 ABOUT HERE]

The limited attention to knowledge accumulation is reflected in the perception of how clustering spurs industrial dynamism. Two mechanisms are distinguished: Marshallian externalities and cooperation, also termed 'passive CE' and 'active CE', respectively. Marshallian externalities are defined as cost advantages due to agglomeration, including availability of a pool of specialised workers; easy access to suppliers of varied and specialised inputs; and quick dissemination of new knowledge and ideas. These benefits have in common '...that they fall into producers' laps without deliberate efforts to bring them about' (Schmitz and Nadvi, 1999:1505). These advantages contrast with 'active CE', which materialises only as a result of purposive actions aimed at generating them. They include advantages arising from deliberate joining of forces between parties to achieve certain common goals, as well as benefits from market-mediated interactions, where parties collaborate to some extent for the purpose of pursuing their own objectives.

The distinction between active and passive CE has intuitive appeal, but on closer inspection it is somewhat problematic. Firstly, joint action and collaborative interactions primarily work, not by generating clustering benefits that are somehow different in nature from Marshallian external economies, but by facilitating the occurrence of the latter. For instance, diffusion of new ideas and information is helped along by intensive interaction between local parties. The claim of CE researchers, that joint action *rather than* Marshallian

externalities has boosted the performance of clustered firms, is thus less straightforward than would appear at first sight.

Secondly, both categories are highly heterogeneous. The ‘passive CE’ concept lumps together static cost advantages with dynamic economies that stimulate knowledge acquisition processes in firms. ‘Active CE’ likewise comprises benefits from cooperation arising from the exploitation of static cost advantages and dynamic economies. Yet, only dynamic economies could reasonably be expected to contribute to a structural improvement of firms’ competitiveness (Maskell and Malmberg, 1999; Cassiolato and Lastres, 2000).

Intra-firm knowledge accumulation processes do occupy centre stage in the technological capability (TC) literature.⁴ Structural improvement in the industrial competitiveness of developing countries requires more than passive adoption of new technologies generated elsewhere. Using a new technology efficiently in a new setting usually requires a firm to gather considerable know-how about its underlying scientific and engineering principles. New knowledge is also needed to make adaptations, which are frequently needed in an environment which differs in many ways from the setting in which the technology was developed initially. Such technological capability cannot be transferred costlessly and quickly along with equipment, blueprints, and user manuals. It has to be built up through purposive ‘technological efforts’: investment in time and resources aimed at assimilating, adapting and improving known technologies, and (ultimately) creating new technologies in-house. Bell (1984) distinguished five main types of such efforts: staff training, staff hiring, in-house technological improvement (including R&D), external search for information about new technologies and markets, and gathering of internal feedback about performance. Some of these are clearly internal activities undertaken within the firm, while others are externally directed and involve active interaction with the firm’s environment. Many studies have drawn attention to the importance of externally oriented efforts as a complement to internal

activities. Reference has been made to the importance of being part of larger ‘innovation systems’ (Lall, 1992; Lundvall, 1988 and 1993; Cassiolata and Lastres, 2000; Edquist, 1997; Freeman, 1995; Maskell and Malmberg, 1999; Nelson, 1993) or ‘cluster knowledge systems’ (Bell and Albu, 1999).

However, a systematic conceptual treatment of how and why regional networks could contribute to intra-firm learning processes is lacking. Bell and Albu supply an *ad hoc* list of intra-cluster and extra-cluster mechanisms, and the reasons why the existence of spatial proximity would confer special learning advantages remain unclear. The problem is that the conceptual toolkit of the TC literature is not well suited to explaining why ‘the whole is sometimes more than the sum of the parts’, and under which circumstances this is likely to be the case (Figure 2). As a result, studies that have attempted to explain technological dynamism of countries or regions (for example, the ones mentioned above) have not been able to do much more than point towards the importance of synergy and complementarity between activities of individual firms, the functioning of technology institutions and the thrust of industrial and technology policies in innovation systems.

[INSERT FIGURE 2 ABOUT HERE]

To sum up, the two bodies of literature yield partial, but complementary, insights into the relationship between clustering and accumulation of technological capabilities. In the remainder of this paper we aim to join the two approaches by combining their insights and elaborating on some aspects which need to be improved (Figure 3). The focus of the TC literature on firm-level learning will be used as a conceptual starting point, in the belief that meso- and macro-outcomes in an economy cannot be understood well unless they are grounded in a theory about the behaviour and decision-making of individual actors. We shall

then bring established theoretical bodies of literature about spillovers, externalities and market linkages to bear on the question of why and how firm-level learning can be triggered, stimulated or otherwise improved through the existence of industrial agglomerations.

We shall start at the cluster level, exploring the relationship between geographical clustering and the incidence of various agglomeration advantages. Then we shall move to the firm level, examining the implications that these advantages may have for firms' technological efforts and the accumulation of capabilities of various kinds through learning processes. Finally, we shall discuss how these capabilities may contribute to improved economic performance of firms and regions, which in turn contributes to national economic growth and catch-up.

[INSERT FIGURE 3 ABOUT HERE]

3. GEOGRAPHICAL CLUSTERING AND AGGLOMERATION ADVANTAGES

The literature on advanced economies uses the term *agglomeration economies* to denote the advantages experienced by firms in a regional network. The general idea behind the concept is that the environment of the firm has a positive influence on its output. Richardson (1978a and 1978b) defines agglomeration economies as everything that induces people and economic activities to cluster together.

What exactly are these advantages that comprise the overall concept of agglomeration economies?⁵ Firms expect to realise various benefits when they settle into a cluster.⁶ In this respect, reference is often made to the three Marshallian reasons for geographic localisation (Marshall, 1920), which are:

- 1) The presence of a labour pool with specialised skills.

- 2) The phenomenon that ‘an industrial center allows the provision of nontraded inputs specific to an industry in a greater variety and at lower cost.’ (Krugman, 1991:37). To these, we should add market access provided by specialised buyers (McCormick, 1999).⁷
- 3) Technology spillovers, which we define as intellectual gains through exchange of information for which a direct compensation to the producer of the knowledge is not given, or for which less compensation is given than the value of the knowledge.

As firms expect these types of benefits to be generated through co-location, they are induced to locate in a cluster. In this way, a cluster grows and the expectations materialise, leading to the emergence of a ‘growth pole’ (Perroux, 1955).

For an individual firm, Marshall’s reasons for localisation within a cluster come down to the expectation (and ultimately the realisation) of three different types of advantages, namely (i) economies of scale and scope, (ii) transaction economies, and (iii) knowledge spillovers. Marshall’s first reason, the presence of a labour pool with specialised skills, points to transaction cost savings for firms. Obviously, a cluster will attract workers with specialised skills, which is advantageous for new firms locating in a cluster. Marshall’s second reason, the provision of non-traded inputs specific to an industry in greater variety and at lower cost, seems to point to scale and scope as well as transaction economies. Marshall’s third reason, technology spillovers, is equivalent to the currently accepted concept of knowledge spillovers.⁸

For individual firms, economies of scale, scope and transaction point to cost advantages (pecuniary gains) accruing from being close to each other, while knowledge spillovers point to benefits arising from real inputs of new information or knowledge emanating from other firms in the cluster.⁹ In this regard, Stewart and Ghani speak of *real dynamic externalities* (a concept which appears to be more or less identical to Marshall’s knowledge spillovers) to indicate that these particular advantages are fundamentally important to economic

development, especially through their effects on activities that foster technological change (Stewart and Ghani, 1991:573). Moreover, they state that these externalities are widely prevalent and potentially substantial.

While the existence of a positive link between clustering and the incidence of economies of scale, scope and transaction is obvious, the same does not hold for knowledge spillovers. Why would information flow more easily across short distances? To shed light on this question, we have to revert to the literature about clustering in economically advanced countries.¹⁰ In one subset of that literature, which can be classified under the heading of economic geography, it is assumed that short geographical distance facilitates knowledge spillovers between firms for five reasons (Audretsch and Feldman, 1996; Feldman and Florida, 1994). These stem from the nature of the innovative process, which can be summarised in five ‘stylised facts’ (Dosi, 1988; further developed by Feldman, 1994a, 1994b; and Baptista and Swann, 1998). These are uncertainty, complexity, reliance on basic research, importance of learning-by-doing, and cumulateness.

The first two refer to the process of generating innovation out of ideas, which is a highly uncertain and complex activity. It is hardly possible to forecast whether an idea will be technically viable and whether it can be developed into a commercial success. In order to reduce this uncertainty, people (firms) try to access information by communicating. Communication is facilitated by personal interactions, and therefore people (firms) tend to group together. Freeman (1991) states that networks frequently tend to be localised. In addition, DeBresson and Amesse argue that ‘localised networks appear to be more durable than international strategic alliances’(1991:370).

The third stylised fact refers to the heavy reliance of innovation upon sources of basic scientific knowledge such as universities and government-funded research and development (R&D).¹¹ Face-to-face interaction with university scientists can make it much easier for a

firm to convert information (from scientific publications) into directly applicable knowledge (Nelson, 1990). Mansfield (1991) presents evidence that technological innovations in various industries have been based on recent academic research. Jaffe (1989) and Acs, Audretsch and Feldman (1992) have shown empirically that knowledge spillovers from university research to private firms are facilitated by geographic proximity.

The fourth stylised fact has to do with new technological knowledge being informal and uncodified in nature (Pavitt, 1987). Therefore, it should flow more easily locally than across great distances. The underlying idea is that knowledge can be acquired through practice. Possibilities for learning-by-doing and learning-by-using come from direct contacts with competitors, customers, suppliers and providers of services (Von Hippel, 1988, 1994).

Finally, innovative activity is cumulative in nature. New innovations build upon scientific knowledge generated by previous innovations. The concept of ‘cumulativeness’ is also highly relevant in the context of geographic clustering. Breschi (1995) and Malerba and Orsenigo (1995) show that cumulativeness of innovative activity plays a key role in shaping the geographical pattern of innovative activity. The underlying idea is that geographic areas (regions) that have accumulated high levels of innovative activity have assembled information that facilitates the generation of new innovations (Grossman and Helpman, 1992).

Even though these stylised facts were formulated on the basis of experience in countries at the world’s technological frontier, most of them appear to be equally relevant to the situation in poor countries. Adoption, assimilation, adaptation and upgrading of older technologies in response to local requirements in these countries are no less fraught with uncertainty and complexity than the processes leading to path-breaking innovations which represent radical advances in the world’s stock of technological knowledge.¹² Knowledge is also informal and tacit, since adaptation of foreign technologies to local conditions entails a

partial re-invention as a result of the existence of local specificities relating to consumer tastes, climate, specifications of local raw materials, and so on. Achieving good fit results from informal learning-by-doing, involving the need for exchange of new, uncodified, knowledge between parties. Furthermore, local networks are still the main information sources for most (especially small) firms in countries with poorly developed communication infrastructures, since they are cheap and easy to tap into. In addition, cumulateness appears to be a universal characteristic of technological change. Firms in developing countries need to go through a lengthy incremental learning path. They generally cannot leapfrog to the world's technological frontier (Hobday, 1994). The only stylised fact which would have less relevance in the context of less-developed countries concerns the importance of basic scientific knowledge generated in universities and research laboratories.

4. AGGLOMERATION ADVANTAGES AND TECHNOLOGICAL EFFORTS

Having analysed the mechanisms through which clustering gives rise to various agglomeration advantages (that is, arrow [1] in Figure 3), we now address the question of how these agglomeration advantages contribute to efforts directed to technological improvement in firms (that is, arrow [2] in Figure 3).

4.1 Insights from literature about advanced countries

The best insights about possible linkages between agglomeration advantages and technological effort can be gained, once again, from literature about clustering in more advanced economies. The main line of argument is that clustering (and proximity in general) has advantages for innovation and economic growth. However, clustering effects are linked directly to innovation and growth, and there is no concept of 'technological efforts' as such.

Moreover, the idea that efforts are aimed at technological improvement by creating specific capabilities for the firm is not made explicit. Firms are assumed to increase their performance in terms of profitability, growth and market share through investments leading to innovation.

Furthermore, the focus of the advanced-country literature is on investment in R&D. Less attention is devoted to non-R&D-based investments for technological improvement (training, hiring, information search and internal performance feedback).¹³ However, as argued by Cohen and Levinthal (1989), R&D is not only an investment of resources for the production of new artefacts, but also a form of technological effort which is an input into a learning process aimed at increasing a firm's capabilities. From this perspective, we can use the literature about developed countries to explore how agglomeration advantages affect R&D as a technological effort which contributes to a firm's capabilities. We shall also (in section 4.3, below) use the literature to make some tentative inferences about the impact of these advantages on other, non-R&D-based, technological efforts which assume more importance in developing-country companies.

Three main mechanisms can be distinguished through which R&D is affected by agglomeration advantages. One mechanism runs through economies of scale, scope and transaction *in the production of goods and services*; the second works through economies of scale, scope and transaction *in undertaking R&D (and thus technological effort) itself*, while the third is associated with *knowledge spillovers*. We shall discuss each briefly in turn.

The first mechanism, economies in production, consists of direct cost advantages in production obtained by clustered firms due to high local demand (Swann, 1998). Clustered firms are left with more financial resources to invest in R&D because they produce more cheaply than non-clustered ones do.

The second mechanism, economies in undertaking R&D itself, works in at least two different ways. First, by lowering transaction costs, clusters allow firms to exploit scale

economies in R&D through joint programmes, allowing them to spread their fixed R&D costs over a larger production volume and to share the risk and uncertainty inherent in the innovation process. For this reason, firms often join networks of innovators (Freeman, 1991; Debresson and Amesse, 1991). Second, pooling R&D resources will induce more R&D investment as well, as it becomes feasible to embark on large, costly projects that are beyond the capacity of individual investors (Baptista, 1998).

The third mechanism, the effect of knowledge spillovers on R&D, works by enhancing its effectiveness. Implementing knowledge from outside the firm increases its chances of success (Nelson, 1993; Feldman, 1994a; Von Hippel, 1988; Baptista, 1998). Firms might benefit from complementarity and synergy effects that arise from the R&D of other firms in the cluster. Spillovers are facilitated by opportunities for firms to establish direct contact with each other in a cluster, such as through inter-firm labour mobility and formal and informal exchange of information and ideas (ibid.).

4.2 Insights from literature about developing countries

For more detailed insights into the nature of knowledge spillovers we turn to Stewart and Ghani's survey of the role of externalities in economic development (1991). The survey did not focus specifically on technological effort and learning, but it is not difficult to tease out the implications for these processes from it.¹⁴ Three types of real dynamic externalities (that is, knowledge spillovers) are distinguished: (i) changing attitudes and motivations, (ii) human capital formation through informal learning-by-doing, and (iii) technology transfer.

Changing attitudes and motivation primarily work by exposing people to new ideas and artefacts in a particular environment. These act on people's mental predisposition in such a way that they will begin to favour change over stability, and thereby stimulate investment in the technological efforts needed to bring it about.

Human capital formation through informal learning-by-doing acts through changing attitudes towards work. It is an effort-inducing mechanism, like changing attitudes and motivations. In addition, learning-by-doing entails assimilation of a basic body of more specific production-related technical knowledge and skills which are common in a local industrial environment. This constitutes a direct free input complementing a firm's own investments in staff training. Thus, this spillover not only affects the demand for technological effort, but also the supply of inputs for it.

Technological transfer acts entirely on the supply side. It operates through three channels: inter-firm movement of trained labour; trade journals, meetings, trade fairs and various other fora for inter-personal exchange; and user-producer interactions which often occur in the course of implementing and perfecting innovations in iterative fashion (Johnston and Kilby, 1975; Ahmad *et al.*, 1984; Nowshirwani, 1977; Fransman, 1982; Cortes, 1979; Basant and Subrahmanian, 1990). The first two channels are horizontal spillovers; that is, they mainly stimulate diffusion of information, skills and knowledge among firms at the same stage in a production chain. The third is a vertical spillover, involving exchange across consecutive stages in a production chain. This channel is likely to be especially important for firms which are linked to global value chains. Inter-firm movement of trained labour boosts skill levels through hiring of new staff; while communication fora and user-producer interactions are primarily sources of free new information and knowledge about technologies and markets, which complement the firm's own search and research efforts.

Less attention is given to the effects of *economies of scale, scope and transaction* on technological effort in Stewart and Ghani's survey. One important effect is noted: clusters can stimulate technological effort by creating a minimum market size for new, specialised goods and services which cannot be produced profitably elsewhere. This will stimulate investment in technological effort needed to engage in new production.

4.3 Summary classification and illustrations

Synthesising the literature reviewed above, we distil a taxonomy of positive linkages running from agglomeration advantages to technological effort (Table 1). In order to simplify the discussion we confine the focus mainly to *direct* linkages; that is, effects which occur without intervening third variables which do not constitute technological efforts themselves.¹⁵

[INSERT TABLE 1 ABOUT HERE]

The five rows in Table 1 represent the five main types of agglomeration advantages identified in sections 4.1 and 4.2, namely: (I) economies of scale, scope and transaction in activities aimed at the production of goods and services; (II) economies of scale, scope and transaction in activities aimed at the production of new knowledge and skills; (III) knowledge spillovers emanating from changing attitudes and motivations; (IV) knowledge spillovers emanating from informal learning-by doing; and (V) knowledge spillovers associated with transfer of technological information. The four columns in the table represent four main types of technological effort identified by Bell (1984), namely: (A) hiring of staff with new skills and knowledge, (B) training of existing staff, (C) search for information about new technologies and markets, and (D) formal and informal R&D.¹⁶ The contents of the cells describe the mechanisms through which the agglomeration advantages affect these technological efforts. We discuss the table row-wise, illustrating each mechanism with examples from the collective efficiency studies and somewhat related literature. Although these studies were not developed with our framework in mind, they do contain some relevant information.

Following the discussion in section 4.1, scale, scope and transaction economies in

production first of all give rise to cost savings (row Ia), which may leave firms with more financial means for undertaking R&D as well as other kinds of technological effort (columns A through D). Unfortunately, there is not much evidence about the successful operation of this particular mechanism in practice. In poor, technologically backward clusters, such economies probably allow clustered firms to compete merely in a survivalist sense.

Competition in low-skill, low-tech activities is so intense that producers have little scope for retaining a substantial part of the cost savings.¹⁷ However, things are likely to be different in more well-to do clusters where firms compete on the basis of a certain amount of skill, and competition is muted to some extent by entry barriers.

Economies of scale, scope and transaction in production may also raise the demand for innovations because of the existence of a large local market, as discussed in section 4.2 (row Ib). This can act on all kinds of technological effort (columns A through D). An example comes from Ludhiana's woollen knitwear cluster in India's Punjab state, where firms' needs for knitting machinery were met by local machinery producers who had been attracted by a large market for their products. They would reverse-engineer and reproduce a foreign prototype at a fraction of its original cost. Knitwear firms also used local technicians to make extensive modifications to their machinery to reduce waste and improve productivity (that is, Ib-C&D; Tewari, 1999:1662). Many similar examples can be found in literature about the role of capital goods production in development.¹⁸

Economies of scale, scope and transaction also occur in activities directly aimed at knowledge accumulation. The review in section 4.1 showed that these type of economies operate first of all by offering possibilities for clustered firms to benefit from shared investment in technological efforts because of low transaction costs associated with local interaction. This increases firms' capacity for undertaking technological effort through cost- and risk-sharing (row IIa). The discussion in section 4.1 focused primarily on R&D-type

efforts (column D), but the mechanism is also likely to work in respect of other activities with scope for collective investment, such as training (B) and search (C).

Local industry associations are often the embodiment of collective strategies pursued by local members. A remarkable example is FEPACH, a federation of agro-industrial producers in Chile, which promoted new quality control practices, encouraging firms to submit their products to external quality control labs for evaluation. It also disseminated information about international standards and production practices and served as a forum among local companies for benchmarking regarding processing yields and volumes, production costs and so on (IIa-C; Perez-Aleman, 2000:48).

Section 4.1 also showed that economies of scale, scope and transaction in knowledge accumulation may operate through low transaction costs associated with undertaking joint efforts, creating scope for overcoming problems with indivisibility through joint action. This may induce new investment in ‘lumpy’ efforts which are beyond the capacity of individual firms (row IIb). A related case is where proximity allows parties to invest in technological effort requiring the commitment of both for it to work, because they need to supply complementary inputs for it. As in the case of row IIa, the mechanism might operate not only in respect of R&D (column D), but also for other efforts where collective investment is feasible, that is, training (B) and search (D).

SIMA, a local trade association in a cluster of surgical instrument producers in Sialkot (Pakistan), illustrates this particular mechanism. In 1994, exporters of surgical instruments faced the need to conform to GMP standards in order to continue exporting to USA markets. SIMA successfully lobbied the Pakistani government for financial support to hire foreign consultants to help upgrade quality management practices. Moreover, it convinced the government to co-finance an internationally recognised local metal-testing laboratory and technical-training facility. For the smaller companies this was the only way to get access to

the required training, information and knowledge. These collective actions thus led to circumvention of indivisibility problems (IIb-B&C; Nadvi, 1999).¹⁹

Interestingly, empirical studies point to the operation of a third important link between economies of scale, scope and transaction in knowledge accumulation and investment in technological effort, which could not be identified from the literature review: the local presence of suppliers of specialised inputs who are attracted by large local demand may facilitate the acquisition, and lower the cost, of technological effort-related inputs for firms (row IIc). This mechanism may influence all kinds of efforts because the actors offering specialised services are manifold, including workers with specialised skills and technical consultants (column A), institutions providing training courses (B), government extension services (C and D), sourcing/marketing agents looking for suitable suppliers (C), suppliers of machinery, materials and components (C and D), and so on.

Ludhiana's knitwear cluster offers much evidence of this mechanism. It attracted a skilled labour pool (IIc-A) due to the presence of a critical mass of knitwear firms, spinning firms and knitwear machinery producers (Tewari, 1999:1667). Also, an internal training programme was started in one firm for multi-skilling of workers in response to high labour turnover due to the activities of a violent secessionist movement in Punjab in the 1980s. Over time, this grew into 15 skill-development centres, many of which are open to workers of other firms as well as to the region's workforce in general (IIc-B). Apparently this initiative has contributed greatly to skill development and resulting enhancement of productivity in the industry (ibid.:1662-3). Moreover, a number of foreign buying houses began to develop sourcing networks in Ludhiana after India embarked on economic liberalisation in 1991. These are catalytic feedback-giving intermediaries, who are key channels for market access, transfer of knowledge and monitoring for local producers (IIc-C&D; ibid.:1654). And as far back as the early 1980s, Ludhiana's knitwear industry had also become a beneficiary of state

and central government programmes under which European and American designers were brought in to help local firms (IIc-D; *ibid.*:1658).

Knowledge spillovers from other firms may complement a firm's own efforts and thereby increase the efficiency of those efforts, as the literature review in section 4.2 showed. Unfortunately, evidence of attitudinal spillovers, including informal learning-by-doing (rows III and IV), is hard to come by. Some circumstantial evidence is provided by the Sialkot surgical instruments study. Producers recognised that the absorption of 'soft technologies' (that is, skills, capabilities and organisation) for production according to GMP standards was much harder than acquiring the hardware. 'An attitudinal shift was required, wherein local producers recognised that traditional practices could be improved upon and were aware of the urgency to do so... The awareness ... was rapid even if the process of upgrading itself was gradual. Discussions on the means to acquire the requisite know-how for upgrading local practices began almost immediately [after FDA's action in 1994, *red.*] especially within the forum of the trade association' (III/IV-B&C; Nadvi, 1999:1610).

In his study of a clothing cluster in Gamarra (Peru), Visser also points towards the importance of progressive attitudes when he says that willingness to look for, select, process and use new information is one of two key conditions that trigger learning. Unfortunately, such attitudes were not being diffused in his cluster. Clustering appeared to reinforce traditional attitudes by exposing producers to the same ways of doing things all the time, producing a situation of 'lock-in' (Visser, 1999:1567). This is clearly a cluster whose participants did not yet possess own capabilities for generating change. In the absence of significant exposure to modern ideas, no significant technological learning was possible.

Evidence about the impact of the technology transfer mechanism (row V) is easier to find, probably because this acts through more specific channels than attitudinal change and learning-by-doing. A firm's hiring activities are affected through inter-firm movement of

labour (V-A); and its search and research activities through communication with, and feedback from, other firms and other parties (Va & Vb - C&D). Visser's study notes that, '... clustered producers enjoy advantages in the form of information spillovers from several sources, such as the products of competitors. Nearness also facilitates the diffusion of still-tacit knowledge and work-in-progress through direct observation. New ideas, whether modest or important, thus quickly become public on a local scale.' (ibid.:1561-2).

Such transfer spillovers often interact with economies of scale, scope and transaction. Low transaction costs in clusters directly facilitate (horizontal and vertical) business interaction, joint projects, and labour mobility, which are the main vehicles through which skills, knowledge and ideas travel across firms. Furthermore, we have seen that economies of scale, scope and transaction boost the amount of intra-firm technological effort in various ways. Clearly, the more actively firms are engaged in learning, the more spillovers to neighbouring firms are likely to result as well. The recipients essentially receive free inputs which complement their own technological efforts and in this way increase the effectiveness of their learning processes. In sum, when economies of scale, scope and transaction work in tandem with knowledge spillovers, both the amount and effectiveness of intra-firm technological effort will receive a boost.

An example of a relatively straightforward interaction effect comes from Ludhiana's knitwear cluster. This cluster grew so large that it allowed considerable scale and scope economies in production and 'learning-by-doing' economies to develop as a result of its extensive division of labour. The build-up of specialised expertise in turn created scope for considerable information spillovers between firms with complementary knowledge (Va&b-C; Tewari, 1999:1661).

The case of FEPACH in Chile illustrates more complicated interaction effects. We have already noted how the collective learning strategies adopted by this organisation generated

dynamic economies of scale, scope and transaction. At this point, it is also relevant to note that the organisation also generated straightforward static economies by serving as a forum on how to regulate price competition between fruit-processing firms. The buyer-firms agreed to stick to common prices for raw material, which lowered transaction costs in the purchase of inputs from small-scale growers. All these different cooperative strategies entailed ‘... much sharing of information among managers of large processing firms, which reinforced knowledge acquisition.’ (Perez-Aleman, 2000:48). In addition, information exchange due to inter-firm movement of managers was noted (ibid.:46). In sum, the FEPACH case illustrates different horizontal spillovers (V-A), which were stimulated by static and dynamic economies of scale, scope and transaction that were captured through joint action. A similar effect was operating vertically in the supply chain, as a result of collaborative activities initiated by the buyer-firms to help their small-scale growers to upgrade fruit quality. Significant know-how was transferred from the buyer-firms through intensive on-site quality monitoring and technical assistance, involving frequent and regular in-plant visits by the firms’ technical personnel (a case of Vb-C, induced by Ila-C). Similar vertical spillover effects induced by collaborative user-producer interactions have been highlighted in Nadvi (1999) and Schmitz (1999).

5. EFFORTS, LEARNING, CAPABILITIES, AND ECONOMIC GROWTH

Having established that agglomerations can boost technological effort in various ways, we turn to the next link in the chain, which runs from effort to learning, to capabilities, and finally to economic performance of firms and regions (that is, number [3] in Figure 3).

The link from technological effort to capabilities through learning is well established in the literature documenting firm-level technological progress in less-advanced countries, but it

only sheds light on processes in individual firms. We outline these insights briefly, and then show how these intra-firm processes feed technological dynamism at the cluster level, and how this in turn feeds back into individual firms' learning processes.

Firms in less-developed countries devote their efforts mainly to acquiring, using, adapting and perhaps improving existing technologies developed by others. This is reflected in the nature of their learning processes and the capabilities which they build up. Many writers classify capabilities in a way which closely reflects the main direction of the efforts undertaken by firms.²⁰ Firstly, there are *investment capabilities*, which refer to the firm's skills and knowledge needed to acquire and assimilate new technologies from outside.²¹ Then there are *production capabilities*, which consist of the skills and knowledge to use and reproduce existing technologies. And finally, there are *innovation capabilities*, the skills and knowledge required to make independent adaptations and improvements to existing technologies, and ultimately to create entirely new technologies.²²

It has often been pointed out that a certain sequence is involved in the accumulation of these three types of capabilities (for example, Chudnovsky and Nagao, 1983; Lall, 1992). Initially, learning tends to focus on accumulating basic skills for assimilation, use and unmodified reproduction of given knowledge. These skills are a prerequisite for entering the intermediate stage of creative adaptation, in which basic design skills are developed along with more advanced investment- and production capabilities. The third stage centres around the accumulation of advanced capabilities for making substantial improvements to existing technologies and creating new knowledge proper, along with developing advanced investment capabilities and process engineering capabilities.

Most of the industrial clusters in less-developed countries are made up of small firms which are still predominantly at the first stage, relying mainly on absorption, use and copying of technologies developed elsewhere (Romijn, 1999). In the absence of internal design skills,

they are highly dependent for further learning on new information, skills and knowledge emanating from outside their local cluster. At this early stage, therefore, regular inputs from actors such as non-local buyers, suppliers, skilled migrant labour, developmental agencies and so on, are particularly crucial. In the absence of regular external stimuli, primitive clusters will stagnate, since their participants do not possess indigenous capacity for generating new knowledge internally or even for extracting and absorbing substantial new knowledge actively from extra-cluster sources.²³

However, primitive clusters which are exposed to regular external inputs, for example by becoming part of a global production chain, could have the potential of becoming technologically quite dynamic due to the mechanisms for rapid and easy diffusion of new information, skills and knowledge present within the locality. By affording ample learning opportunities, such clusters can help firms to accumulate relevant technical experience, enabling them to move up the learning ladder from basic assimilation and copying skills to internal adaptive design capability more quickly than they would be able to do on their own. Having reached that stage, firms begin to make an independent contribution to knowledge accumulation, and fertilising each other with the fruits of their own new ideas. Clusters in which firms have reached this stage have established an internal learning dynamic.²⁴

After some time, this dynamic is boosted not only by development of indigenous design capability, but also by an increasing capability to manage the technological learning processes efficiently. This capability is known as the capability to learn, and it is built up as a by-product of the technological learning processes described above. As stated by Stiglitz, ‘experience in learning may increase one’s productivity in learning. One learns to learn at least partly in the process of learning itself’ (1987:130). The idea originates in studies about technological change in economically advanced countries, where learning to learn is often a goal in itself. Cohen and Levinthal argue that firms in advanced countries engage in R&D not

only to pursue new product and process innovations, but also to increase their general knowledge. This makes them capable of assimilating knowledge spillovers from outside the firm. In their own words, ‘...while R&D obviously generates innovations, it also develops the firm’s ability to identify, assimilate, and exploit knowledge from the environment – what we call a firm’s “learning” or “absorptive” capacity’ (Cohen and Levinthal, 1989:569).

By contributing to capability building in a locality, clustering has the potential of contributing significantly to improved economic performance and the competitive position of firms and, through this, to regional economic growth and eventually catch up with other countries. Although hard quantitative evidence of a positive link between the accumulation of capabilities (and the efforts undertaken for that purpose) and improved enterprise performance is hard to come by, there is sufficient circumstantial evidence to suggest that such a link does exist, not only for large firms²⁵ but also for small-scale workshops and even tiny activities in the informal sector (King, 1974 and 1996; Cortes, 1979; Cortes *et al.*, 1987; Aftab and Rahim, 1986; Child and Kaneda, 1975; Gupta, 1994). No hard and fast requirement of minimum size or technological competence level appears to be required for technological accumulation to occur, and its benefits to materialise.

Some salient aspects of the technological learning trajectory outlined above are illustrated by two studies that addressed ‘learning’ in a broad organisational / institutional (if not strictly technological) sense. They are especially insightful about the contribution of clusters to *learning* capability in firms (Perez-Aleman, 2000; and Tewari, 1999).

In Chile’s agro-industry, the technical assistance and quality control by the fruit processors for their small-scale fruit suppliers ‘went beyond the mere function of transferring know-how;it became part of a system of coordination that increased *the capacity for learning* by monitoring’ (Perez-Aleman, 2000:46, emphasis added). This involved the establishment of routines for constant evaluation of actual against target performance at every

step of production, which in turn formed the basis of improvement of production performance at every step (that is, for improved production capability). Ludhiana's knitwear case, too, illustrates the emergence of different capabilities. Technological capabilities initially included problem-solving production skills related to quality, customisation and productivity; later followed by design (that is, innovation) capability along with more-advanced production capabilities related to finishing, scheduling and quality control. In the process, some firms also developed a capability to learn. This became evident when their stable, high-volume but undemanding Soviet market collapsed in 1991. Those producers that had simultaneously built up experience of catering to the more-competitive high end of the Indian domestic market were best placed to make a quick adjustment and build up new high-quality and design-conscious markets in the west. This was because '...they had developed an ability to assess demand, understand different market structures, develop niches, and build a production organization that was able to service two very different markets simultaneously... This provided firms with the experience of developing complex management structures. It forced them to manage a diverse supplier base and organize complex distribution networks. This extensive experience at managing, organizing, and coordinating production for different market segments provided firms with problem-solving skills abilities that proved crucial to their ability to shift to new, more demanding external markets in the 1990s' (Tewari, 1999:1660-1).

The two cases cited appear to have emerged as economically highly competitive clusters. Both have managed to secure market niches in highly demanding western markets and are contributing significantly to regional prosperity. In Chile's case, collaborative strategies mediated through emerging developmentally oriented institutions played a highly important role. The Ludhiana case, however, appears to illustrate primarily the importance of spontaneous growth-pole effects. This cluster clearly acquired critical mass at some point

through its sheer size and highly diversified internal structure.

Peru's Gamarra cluster (Visser, 1999) and Java's traditional rural clusters (Weijland, 1999) appear to represent the other extreme of the spectrum. The contribution of clustering to capability accumulation appears to have been severely limited because there was very little intra-firm technological effort to begin with. In its absence, it would appear that the so-called 'spillovers' noted by the researchers appear to have consisted mainly of recycling a lot of old (or only marginally new) knowledge around localities, confirming producers in their traditional beliefs and attitudes about ways of doing things. Lack of collaborative strategies may be one reason for this kind of 'lock in', but the problems are likely to run much deeper. In circumstances where opportunities to gain from collaboration are themselves limited, collective learning-focused institutions are unlikely to emerge.

6. CONCLUSIONS

Accumulation of technological capability is crucial for the ability of small and medium manufacturing enterprises to make a significant contribution to local industrial development in the context of liberalisation and international economic integration. The conceptual framework developed in this paper sheds light on how that process could be fostered through geographical clustering. It spells out how different agglomeration advantages stimulate or trigger technological learning through investment in technological effort, and how this contributes to durable improvements in economic performance and competitiveness. An improved understanding of these processes constitutes a necessary first step for getting a better grip on the forces that lie behind the economic dynamism or failure of SME clusters in industrial development.

Some key observations can be made on the basis of this exercise. Firstly, in order to

compile a comprehensive taxonomy of causal linkages between agglomeration advantages and technological effort, a broad array of economic and economic-geography theories relating to developing countries as well as advanced economies were explored. This procedure appears to have generated considerable value added. First, by taking received theory as a starting point, the framework can help to infuse some much-needed conceptual clarity in this field of research. Moreover, it would not have been possible to identify a comprehensive set of contributing factors without casting the net so widely. While the taxonomy includes some mechanisms that have already been pinpointed in earlier studies about the dynamics of SME clusters (notably those associated with inter-firm cooperation), it also threw up others that have received only cursory attention or which appear to have escaped notice altogether. These relate especially to the effects of cost advantages, and of spillovers inducing attitudinal and motivational changes. Possibly, these factors have received less attention because they are intrinsically much harder to observe than inter-firm collaborative mechanisms, and also since researchers did not employ a conceptual toolkit that led them to explore in these particular directions.

To the extent that collaboration is indeed important, our framework suggests that its content and purpose might be vital. Cooperation entailing technological learning is likely to have a much bigger impact on economic performance and long-run competitiveness than cooperation for the purpose of managing production, such as joint purchase of inputs and lobbying for tax relief.

Important issues for further research can also be derived from the framework. For instance, it suggests factors that may affect the impact of clustering on technological learning and long-run competitiveness of regions, such as inter-industry differences in technology. Industries in which economies of scale and scope are large could be expected to benefit more than industries in which these economies are small. Opportunities to profit from large

markets and complementarities arising from an extensive division of labour are greater in the former than in the latter. A somewhat similar argument holds for economies of transaction which can be gained through clustering. These economies are likely to be much larger in industries characterised by fast technological change than in slow-changing industries, because uncertainty and risk tend to be higher and knowledge tends to be less codified in the former than in the latter. As a result, the incentives to engage in joint action could also differ across industries. This could be one reason why attempts at establishing learning-oriented collective institutional arrangements have hardly managed to get off the ground in some places, whereas they have thrived in others.

Another factor is economic in nature. Our framework suggests that geographical clustering of industry cannot be expected to exert much of a positive influence on regional economic prosperity when there is no scope for exploiting opportunities for technological learning. Firms have to face concrete incentives to invest in technological effort in order to meet a competitive challenge; that is, there must be *demand for technical improvement*. Only when such incentives are present can firms be expected to develop an active interest in engaging in training, hiring, searching and tinkering on the shop floor. Only then will the potential learning benefits offered by clustering begin to materialise, because it is only in those circumstances that the various mechanisms set out in our framework can come into play. In this kind of situation, supply-side interventions aimed at overcoming critical missing resources, including attempts to strengthen local collective institutions, are likely to stand a good chance of success. However, it will be much more difficult to create dynamic clusters by means of this kind of support in a situation of stagnant markets. No amount of coaxing of firms to undertake collective action is likely to help unless simultaneous efforts are made to make the support 'demand-led' by connecting producers to more dynamic market channels, as Tandler and Amorim (1996) showed. In the absence of individual capability-building

efforts by firms, there can be no cross-fertilisation through new ideas, knowledge and information either. Clustering is no panacea.

These observations suggest the need for empirical work in which these issues can be explored more systematically. The framework developed in this paper is essentially a basic conceptual blueprint which can guide such research. It characterises how the process of technological capability accumulation in an industrial region actually works, providing conceptual focus and helping to pinpoint important factors that are likely to affect the nature and strength of the relationship between regional agglomeration on the one hand, and technological capability accumulation and long-term competitive performance on the other. Understanding the nature of the process is the first step in getting to grips with the long-run development dynamism of regions.

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Figure 1: Analytical perspective of the CE literature

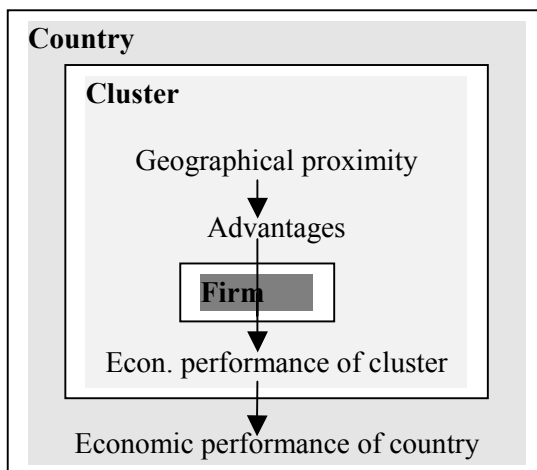


Figure 2: Analytical perspective of the TC literature

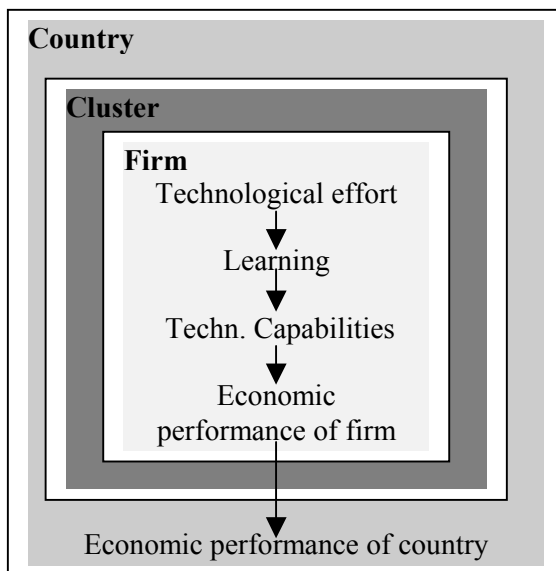


Figure 3: Analytical perspective of this paper

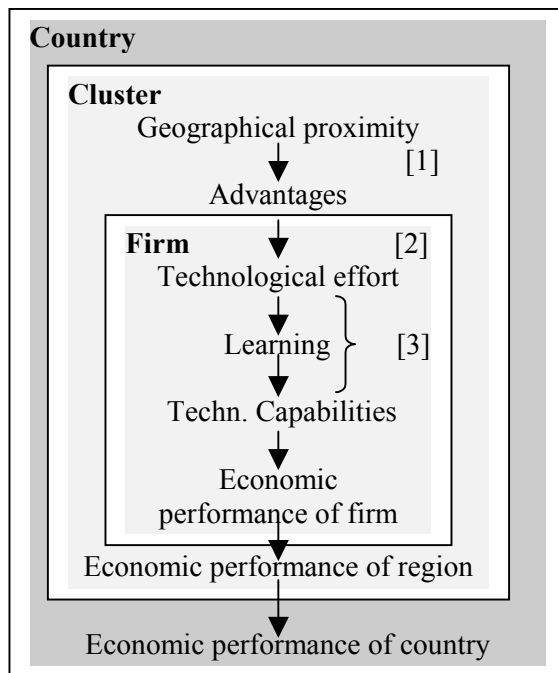


Table 1: Direct effects of agglomeration advantages on the technological efforts (TE) of the firm

Agglomeration advantages	A. Hiring	B. Training	C. Information search	D. R&D
I. Economies of scale, scope and transaction in production	a) Lower unit cost due to large market size leaves more resources for technological effort.			
	b) Large local market gives rise to critical minimum demand for innovations, inducing technological efforts to develop them.			
II. Economies of scale, scope and transaction in knowledge accumulation			a) Low transaction costs facilitate joint undertaking of technological efforts, thus leading to cost-savings.	
			b) Low transaction costs stimulate <i>additional</i> technological effort in joint lumpy and complementary projects, which in turn facilitates access to, and leads to generation of, new information and knowledge.	
	c) Presence of specialised suppliers lowers transaction costs, which facilitates easy and cheap access to specialised inputs needed for technological effort.			
III. Knowledge spillovers: Changing motivation and attitudes	Exposure / demonstration effect / contagion stimulate demand for TE.			
IV. Knowledge spillovers: Human capital formation through informal learning-by-doing	a) Exposure / demonstration effect / contagion stimulate demand for TE.			
			b) Direct free input through industry-wide accumulation of skills	
V. Knowledge spillovers: Technology transfer	Direct free input through inter-firm movement of trained labour.		a) Direct free knowledge input through trade journals, meetings, fairs, etc.	
			b) Direct free input through user-producer interaction.	

NOTES

¹ A notable exception is Bell and Albu (1999).

² For example, Schmitz (1995), Schmitz and Nadvi (1999), Humphrey and Schmitz (1996), Nadvi (1996), Tewari (1996), Rabellotti (1997), Ceglie and Dini (1999), UNCTAD (1998), and the theme issue of *World Development*, Sept 1999.

³ Humphrey and Schmitz define ‘upgrading’ as improvements in processes and products, and moving into higher-value added operations, specifically in the context of global value chains (2000:3).

⁴ For example, Katz (1987), Bell *et al.* (1984), Lall (1987), Amsden (1989), Westphal *et al.* (1984), Fransman and King (1984), Stewart *et al.* (1992), Hobday (1995), Biggs *et al.* (1995), Lall *et al.* (1994), Dahlman *et al.* (1987), UNCTAD (1996), and Romijn (1999). Lall (1992) and UNCTAD (1996) are good reviews of the literature.

⁵ In the remainder of the paper, we use the term ‘agglomeration advantages’ rather than ‘agglomeration economies’, since knowledge spillovers are one category of advantages generated by agglomerations which do not constitute ‘economies’ in the strict sense of the word.

⁶ Clustering may also give rise to disadvantages, for example due to congestion. However, in this paper we only address the positive effects.

⁷ Hirschman also refers to this mechanism when he argues that economic development is essentially a process by which complementary industries create for one another inducements to invest in new activities (Hirschman, 1958:66-67).

⁸ We prefer to speak of ‘knowledge spillovers’ rather than ‘technology spillovers’, conforming to current practice.

⁹ Some authors refer to economies of scale, scope and transaction as ‘pecuniary externalities’, where externalities are defined as advantages that arise when the price of the transaction which give rise to them does not fully incorporate all the benefits associated with them. Knowledge spillovers appear to be the equivalent of what some authors have called ‘positive real externalities’. Stewart and Ghani (1991) discuss the various concepts. However, since some advantages are external to some firms but can be appropriated by others in a cluster (see: Hirschman, 1958:66-67), we prefer the term ‘agglomeration advantages’ to ‘externalities’.

¹⁰ A literature survey about clustering and knowledge spillovers in advanced countries is in Caniels (2000).

¹¹ The extent to which this is the case might differ across industries.

¹² Uncertainty is particularly severe in societies where the infrastructure needed for the efficient diffusion of information is poorly developed. Information problems are especially severe for the poor, the income group to which many entrepreneurs and workers in the SME sector belong. Complexity is also prevalent, since poor education creates formidable barriers to people's abilities to 'unpackage' technologies, even those that are, objectively speaking, 'simple' (Romijn, 1999).

¹³ The most likely reason for this is that in advanced countries, hiring, training and information search are facilitated by the knowledge infrastructure, so firms cannot distinguish themselves from others on the basis of these activities.

¹⁴ The main focus of Stewart and Ghani's work was on economic growth. As part of their analysis, they reviewed the effects of externalities on technological change, since the latter is a powerful engine of growth. Their concept of 'technological change' is an all-embracing one, which also includes straightforward adoption of new technologies. Adoption in itself does not constitute investments in capability building.

¹⁵ An example of an indirect linkage is cost savings in production which provide incentives for firms to expand, which in turn calls forth the need for new capabilities, and thus efforts to build them up. Another example is critical minimum market size for new production facilities, which indirectly increases the need for new capabilities to choose, install, start up and operate new production techniques. Investments in new production facilities could even have a further 'third-order' effect on technological efforts by intensifying local competition.

¹⁶ We ignore the fifth main category identified by Bell, internal performance feedback, since it is unlikely to be influenced by factors external to the firm.

¹⁷ A study of Peruvian clothing SMEs in a municipal district of Lima did find lower production costs among clustered producers than among non-clustered ones, due to scale and scope economies and more extensive experience. However, the accumulated savings tended to accrue to traders of final products due to fierce competition among actors along the supply chain (Visser, 1999:1562). A study of poor clusters in rural Indonesia likewise notes that producers are not always in a position to boost technological effort as a result of static cost savings (Weijland, 1999:1519).

¹⁸ A survey of literature about technology copying and adaptation in small-scale capital goods firms is in Romijn (1999). Many of the cases reviewed concern clustered production.

¹⁹ SIMA also helped to reduce the cost of training and information through transaction cost savings and attraction of public subsidies (that is, a case of IIc-B&C in Table I). Moreover, the larger, wealthier firms in the cluster could have acquired the expertise individually (in fact, one firm had already done so before SIMA took

action). However, it would have cost them dearly. This is thus straightforward cost reduction through joint action (IIa-B&C) rather than inducement of extra technological effort through overcoming lumpiness (IIb-B&C). Other interesting examples of IIa and IIb are in Schmitz' Sinos Valley shoe study (1999), but the collective strategies failed after some time.

²⁰ The classic reference is Dahlman *et al.* (1987).

²¹ The term appears to relate only to process technologies, but skills and knowledge required to assimilate new *product* technologies are also crucial in developing countries, particularly in engineering industries (for example, Romijn, 1999).

²² Lall (1992) uses a slightly different classification of investment, production and linkage capabilities.

²³ Several writers on SME clusters in developing countries have indeed noted that relatively 'closed' systems tend to have difficulties in sustaining competitiveness in the longer term (for example, Nadvi, 1999; Rabellotti, 1997; Visser, 1999).

²⁴ In this connection, Bell and Albu (1999) distinguish clusters that are primarily 'knowledge-using' from clusters that have learnt to engage in 'knowledge-changing' activities. The distinction is rather similar to our distinction between the basic phase of assimilation and reproduction and the intermediate phase of creative adaptation. However, we believe that the ability to generate new knowledge internally is ultimately crucial for creating and sustaining indigenous technological dynamism in firms (and by implication also in clusters). Bell and Albu's requirement appears to be less stringent. Their knowledge-changing capabilities encompass elements to do with knowledge absorption alongside internal knowledge-creation.

²⁵ For relevant evidence in large firms, see mainly Bell *et al.* (1984:118-9).



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