COMPLEMENTARY INNOVATIONS AND GENERATIVE RELATIONSHIPS: AN ETHNOGRAPHIC STUDY

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The paper presents an in-depth investigation on a promising innovation, kervit, in the historical context of the booming ceramic industrial district of Sassuolo-Scandiano (Emilia-Romagna region in Italy). The kervit was introduced and patented by a brilliant inventor operating within, and then leading, one of the first ceramic companies of the booming district. The innovation had strong technological advantages and good market possibilities, but in the middle of the 1960s, right in the stage of sharp growth of the ceramic district, it was unable to exploit its market success, nor was the inventor’s company able to survive.

The joint use of the ethnographic method and the notion of generative relationships, put forward by Lane and Maxfield (1997), marks an original contribution in the analysis both of the emergence of learning processes within a local productive system and of the role of dynamic complementarities in fostering the innovation dynamics.

Keywords: dynamic complementarities; innovation dynamics; generative relationships; local production systems; patents

JEL Classification O30; L60; N84

1 INTRODUCTION

Why is it that, after two decades of successful use on an industrial scale, with a couple of dozen licences granted to firms in various overseas countries and a marked degree of competitiveness in terms of cost, a technology is abandoned even though several of its basic characteristics will become standard in subsequent decades? What are the conditions in which patent
protection of a production method can actually bring about a decline in the use of the patented technology?

This paper offers an answer these questions by pointing out the irrelevance of natural technological trajectories in the process of innovation and highlights the way in which the technical developments under discussion present marked discontinuities. These can be explained by the fact that in the development of a new technology there are not just elements of technical necessity but, rather, path-dependent processes come into play influenced by heterogeneous and contingent factors – technical, social, economic factors and, to some extent, also political and institutional factors – that interact to produce the particular form of technological development which we finally observe.

The process whereby knowledge is created and transmitted is a critical aspect in the analysis of how innovation comes about. The dynamic dimension of this phenomenon requires us to identify the analytical tools which will enable us to define and interpret the historic sequence of different, but endogenous, spatial interactions – between agents and between agents and artifacts – by means of which codified knowledge, tacit knowledge, technical practices and cultural values are interwoven and fused into a specific local fabric which sustains and fuels innovation. To understand the laws of the aggregate dynamics of localized technological change, in this paper I shall adopt an ethnographic method and shall use the notion of generative relationships put forward by Lane and Maxfield (1997). This notion provides an appropriate language to single out and describe the elements that define the dynamics of changes of the agents and artifacts space.

In section 2 the paper presents an overall picture of the topics to be discussed in the empirical analysis; section 3 illustrates the relevant features of the ethnographical method I have used in collecting the data for this study and summarizes the Lane and Maxfield's notion of generative relationships. Focusing on changes in the agent artifact space in which kermit emerged, section 4 outlines the social, technical and economic features of the kermit technology, while section 5 points out the critical aspects marking its demise. Lastly, referring both to the dynamics of innovation in a local production system and to the more general analytical aspects of the innovation process, section 6 summarizes the chief conclusions to be drawn from this study with regard to three main issues: the need for continuous monitoring and fostering of generativeness of relationships, the
emergence of new competences, the social dimension of patents and dynamic complementarities.

2 THE ISSUE: LOCALIZED KNOWLEDGE, PATENTS AND DYNAMIC COMPLEMENTARITIES

The empirical research concerns the case history of kervit*, a radical innovation in the production of ceramic tile which was first tested by an Italian firm at the end of the 1930s and protected by various patents obtained at the end of the 1940s. For about twenty years, the firm that had initially patented and introduced it (S. A. Industria Ceramica Veggia) was also responsible for building all the machines and equipment needed to improve the technical and economic efficiency of kervit. After two decades of improvement in its use on an industrial scale during which a couple of dozen licences were issued to various firms in European and Latin American countries, the kervit technology went out of use owing to the closure of the company that had patented it.

When kervit was abandoned in the mid-1960s, Italian tile production was being launched on the rapid growth that has characterized one of Italian industry's most dynamic districts – namely, the ceramics district of Sassuolo-Scandiano (in the provinces of Modena and Reggio Emilia in Emilia-Romagna region). The history of kervit, therefore, takes us up to the opening stages of a local production system† and enables us to see how the process of training technical expertise within the firm that introduced the innovation gave origin to wide spillovers that allowed the sedimentation of massive tacit knowledge in the local production system. In particular, kervit became a shining example, not only of what to do in technical terms, but also of what not to do in economic and social terms.

Let us first of all consider the overall framework in which to locate the kervit story: the birth of the ceramics district, a district strongly oriented towards exports and where interaction between producers and users of machines have played a central part in the development of the system (Russo, 1985). In the initial stage of development of the ceramics district,

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* The name kervit is an acronym composed of the first three letters of the Greek word keramos (ceramic) and the Latin word vitrum (glass).
† On the notion of local production system, cf. Bellandi and Russo (1994).
the main worldwide producers of ceramics machines were large German and British engineering firms. With the expansion of the market, concentrated in a very limited area, these firms were joined – and shortly replaced\(^*\) – by new firms born in Italy in the ceramics district in order to produce a vast range of machines and equipment devised ad hoc, with the aim of meeting the growing demand for automation in the tile-producing process, but also of extending the range of products, reducing energy consumption and satisfying the ever-increasing environmental regulations\(^\dagger\). Even now, these engineering firms, mostly small\(^t\), generally specialize in developing and setting up one or more stages needed to produce a single type of machine, and rely on a complex network of engineering subcontractors also producing for other engineering industries in the region – e.g. automobile engineering for sports cars and luxury models (produced by Ferrari, Bugatti, Maserati), tractors, machines for the food industry. The subcontractors for firms producing ceramics machines seldom do additional work for other sectors: the mechanical stages and components they produce generally occupy a lower band in terms of the tolerances requested. However, their proximity to engineering firms that are more exacting from the technical point of view represents a continual source of enrichment of technical skills, owing to the mobility of workers (Brusco, 1982; Russo, 1985; Bellandi, 1989).

\(^*\) German and British ceramics machine producers abandoned that specialization in favour of others in the machine sector.

\(^\dagger\) In a comparative analysis regarding Italy, Spain, France and Germany, the effects of environmental regulation on the competitiveness of the firms in the ceramic district are discussed by Russo et al. (1998).

\(^t\) When kermit was invented there was no small business system; there were only three firms. It was not until the early 1960s that a host of new tile producers and ceramics machinery manufacturers made their appearance, specializing in production and forming a tight network of sub-supplier relationships. The reference to small business should therefore be related to the phase in which kermit development reached its peak. As far as the size of the business is concerned, it should be referred to the size of the market. In the absence of economies of scale of a different nature, the years 1930–1950 saw technical economies of scale in tile production which were influenced by the capacity of the kilns, which at that time was around 1000 square metres a day for firing pressed material and around 300 square metres a day for glazed material. It was hence a very small dimension compared with the size of the market and not prohibitive compared with the investment necessary to construct a plant of minimal efficiency dimensions. When the 1960s witnessed a dramatic increase in domestic demand, the absence of barriers meant that a lot of firms set up in the ceramics industry. From the end of 1970s, the size distribution of tile-producing firms was modified by continual mergers and take-overs, so that today it is largely characterised by the presence of some large groups (Russo 1996).
In characterizing the Sassuolo ceramics district it is thus necessary to keep in mind not only the multiple interactions between the engineering firms producing ceramics equipment and between these and the ceramics firms that use them, but also the interactions between all these and other firms — operating in the vertically integrated sector of tile production — that specialize in graphics, or transport services or in the many other commercial, administrative, technical and financial services. The majority of these firms are located within the ceramics district, which comprises an area of about 50 sq.km.

The extraordinary complexity of the system we see today could hardly be conceived in the 1950s, when the kervit technology underwent its maximum expansion and Industria Ceramica Veggia produced in-house not only all the intermediate goods needed to manufacture kervit tiles, but also the machines and equipment employed in the production process.

In tracing the history of kervit I shall show that the decision to abandon this production method was not due to the assumption that it had been economically and technically outgrown: the available documentation shows that it was remarkably competitive already in the 1950s (Vecchi, 1952) and recent estimates still assess it as a competitive technology*. The technology to produce kervit tiles contained some of the basic ideas that feature in the technical development of what, over the last twenty years, has become the leading technology at world level in the production of ceramic tiles: single-firing production. However, kervit was not abandoned owing to its being “way ahead of its time”. My explanation is that kervit was dropped as a result of the gradual reduction, in the 1960s, of the generative potential of the relationships that, in the previous decade, revolved around the kervit technology: the mental closure of kervit’s inventor with respect to the space in which he operated led him to underestimate the entity of the ongoing changes.

To support my argument I shall propose a historical analysis of the social and economic context in which the kervit technology emerged, developed and was subsequently discarded: this will shed light on the main actors and artifacts in the innovative process and will underline how interactions

* The hypothesis in this cost calculation is a production of kervit tiles using present-day firing, glazing and movement techniques. In these conditions, the cost of kervit tiles would be competitive with that of tiles of similar porosity and thickness (Cf. comment by engineer Franco Canevalli in the second meeting with Dal Borgo, coded as 2DB, before 2DB47; see section 3.1).
between actors change in time the environment in which they operate. It will further point out changes in attribution on the part of agents both of other agents and vis-à-vis the artifacts, and will highlight the endogenous and exogenous conditions that alter the generative potential of relationships, marking the demise of the innovation in question. It is by now widely recognized that the historical analysis of technologies that are abandoned demonstrates elements which are generally less visible when success stories are studied*. Here, the case study of a failure enables us to ascertain to what extent the lack of continuous monitoring of the generative potential of relationships can influence the dynamics of the innovative process.

In this paper, analysis of the generativeness of relationships becomes also the key element for discussing the role of patents in assessing innovative activity in local production systems. The empirical analysis presented in this paper highlights that, even if there may be products and production methods whose original features make them suitable for patent registration, the full production and commercial exploitation of many patented innovations requires the construction of a network of relationships which are not only technical, productive and organizational, but also social and economic. Analysis of the social context in which the patented innovation has meaning for those who use it—an aspect generally overlooked in the economic analysis of patent registrations—thus becomes a crucial issue in the research† because such an analysis may actually turn out to be more conclusive than merely calculating the number of patents.

Economists by now tend to consider some of these aspects when observing that complementary assets or capabilities must be utilized in conjunction with innovation (Teece, 1986; Antonelli, 1999): to take full advantage of the patent, the innovative agent has to decide whether to vertically integrate them with the innovation activity of the firm, or to implement partnerships with the owners of those complementarities (Teece, 1986). According to this view, these complementarities are considered as already existing. In this paper, instead, I will argue that they emerge as an outcome of the interplay between the industrial dynamics and the dynamics of inno-

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* This point was first pointed out by Hågerstrand (1965, 1968) and more recently restated in the work by Law and Callon (1992) on the TSR.2 airplane project. For a systematic enquiry into the conditions which accompanied the success or failure of a sample of over 200 innovations see the celebrated Sappho enquiry conducted in Great Britain in the early 1970s (cf. Rothwell et al., 1974/75).

† Cf. Hughes (1971) and Carlson (1992).
vation. The basic idea is that a new product or a new production process nearly always needs to be accompanied by complementary innovations which are only developed if there is sufficient demand to sustain the effort needed to innovate. In these conditions, if the innovating firm patents the innovative product or production process, but does not generate sufficient demand to induce other firms to develop necessary complementary innovations, and moreover lacks the expertise to develop them in house itself, then patent protection actually restricts expansion right the way through the innovative process.

One reason for this restriction is explained in terms of network externalities, generally associated with networks of consumer goods users (Katz and Shapiro, 1985, and Arthur, 1989). But what the kervit story enables us to highlight is that such complementarities are also generated in the expansion stage of a new industry or new technology, when the increasing demand provokes the emergence of new actors specializing in one or more stages of the entire process of production of machinery, intermediate goods, semifinished products, and services needed for the new technology (Bonifati, 1999). What we have, then, is that complementarities of production are associated with the growing roundaboutness of the production processes (Young, 1928). In these conditions, if the patenting firm does not represent a sufficient source of demand, the patent protection may prevent the patenting firm from exchanging information with other agents who might otherwise contribute to solving technical problems which normally arise while the innovation is being fine-tuned (Rosenberg, 1982).

In this framework, we are interested in examining the complementarities emerging within the innovation process (Rosenberg, 1996), and not only those already existing and that agents are ready to use; in other words, we are interested in the dynamic dimension of complementarities. The kervit story thus helps us also to understand in which particular ways the firms operating in a local productive system appropriate the benefits deriving from innovation — ways that require us to interpret the recourse to patenting in an ampler perspective than the one traditionally adopted by economists.
3 CONCEPTUAL FRAMEWORK AND METHODOLOGY

By abandoning the traditional methods of analysis we are forced to define the analytical tools and also the most appropriate vocabulary to be adopted in the research project. In particular, we need to take into consideration not only the agents' characteristics but also the history of interactions between those agents: in this case study it is thus necessary to reconstruct the social, technical and economic processes within which the dynamics of change in the agent and artifact space brought about by the kervit innovation can be described and interpreted.

In collecting data relevant to the analysis of the kervit innovation I have favoured a method put forward by ethnographers, who, making use of open interviews, describe the subjects and the artifacts in the social and economic environment in which they operate, without imposing on the subject the conceptual categories of the person carrying out the study*. The aim is, then, to “view the world through the eyes of the interviewees”.

In fact, if our objective is to understand innovation as a combination of changes both on the cognitive and on the structural level, ethnographic analysis can help in defining an enquiry method to understand how the actors in the innovation process perceive and categorize reality. Such a method enables us to perform a historical analysis of the interactions which constitute the relationships between the agents who initiated the innovation process.

In this section, together with the ethnographic method adopted in the research (section 3.1), the particular vocabulary that I use here (summarized in section 3.2) will be made explicit.

* One helpful reference for setting up this enquiry method is the work done by Spradley (1979) who outlines a methodology for ethnographic research: it ranges from how to decide on who to interview, to specifying the various phases of data collection and the elaboration of relevant information. For a discussion of the use of the ethnographic method in analyzing situated actions (in which the context the action develops in is modified by that action) see Suchman (1987). A wide overview on the characteristics of the ethnographic method is presented by the challenging first chapter of the second edition of Agar's Professional Stranger (1996).
3.1 Ethnographic method to describe and interpret the dynamics of innovation

Ethnography is not merely description, but also analysis and interpretation, this is why any study intending to call itself “ethnographic” must satisfy the two following conditions:

a) An ethnographic analysis must utilize different types of data from several sources so as to have a “massive over-determination of pattern”, without which it would be impossible to construct and interconnect the multiple “frames” (understood as “knowledge structures”) needed for the analysis and interpretation of the phenomena of study.

b) “New concepts have to exist at the end of the study that didn’t exist in the original research problem”: no abduction no ethnography, Agar reminds us (p. 39).

Keeping in mind these two conditions, let us start by noting that the ethnographic method entails using first-hand sources, study of which involves entering into relationship with whom is being studied, participating in what they do, and observing what happens. Obviously this has not been possible in the present paper. However, in reconstructing the events that took place between the 1920s and the 1960s, I have been able to draw on the first-hand experience of Antonino Dal Borgo, the kervit inventor, whose readiness to co-operate enabled us to compile a large part of the documentation needed for this case study. Around 8 hours of conversation were recorded during four different sittings. Following a preliminary literal transcription of the first two recorded interviews, the texts were reviewed and corrected by me, and subsequently revised by the interviewee and discussed in the two later sittings. These revisions were necessary in order to give greater definition to themes developed in later questioning. But they were also necessary in order to verify that in the literal interview transcriptions the punctuation had not altered the sense of the written text in respect of the spoken original. These revisions are given as annotations to complete the transcriptions of the first two interviews*. The preliminary texts are an important part of the ethnographic work, as regards both method and ethical level.

* References to the first two interviews are indicated by the codes 1DB and 2DB, followed by a number which refers to the enumeration of Dal Borgo’s statements. Other sources are cited in the text.
Processing the material collected in the interviews brought out some unexpected elements (what ethnographers call "rich points") which improved our understanding of the context in which the kermit story unfolded and made it necessary to alter the working hypotheses. As well as Dal Borgo, it was also possible to have long interviews with Silvio Lusuardi, former mechanic at Ceramica Veggia since the 1950s, and Franco Carnevali, one of the first engineers to be hired by a ceramics firm in the Sassuolo district. After some years as consultant in an important office in Turin, Carnevali was called to the firm at Veggia by his brother-in-law (a son of Dal Borgo) in order to lend a hand in "tidying up" the father's technical domain. The experience acquired by Carnevali in the subsequent decades as production manager in one of the main groups of the district makes him peculiarly able to assess the elements of continuity and discontinuity that gradually emerge in the kermit story. As well as the aforesaid material and interviews with various technicians, attention has also focused on interviews, performed in a previous research into innovation*, where fleeting reference was made to kermit. Those very elements collected in previous interviews aroused my curiosity on a particular aspect of the growth of the district: kermit was cited as a technology that comprised in a nutshell essential elements of what became the currently dominant technology, but nobody gave a satisfactory explanation as to why kermit was abandoned. Here was a golden opportunity for me to investigate directly Dal Borgo's experience: the available technical documentation would have been quite inadequate, being very fragmentary and imprecise; suffice it to recall that even the patents regarding kermit cannot be found, for kermit has been overtaken by so many other matters in Dal Borgo's life that he has lost all trace of these patents.

One critical aspect of the documentation, emerging from the interviews, concerns the unfolding of the kermit story as put forward by Dal Borgo and the role in it assigned by him to other actors involved in the development of this technology – first and foremost, Maurizio Korach, his mentor and collaborator in the theoretical formulation of the kermit technology, but also other producers, their employees, and the world of politics and society between the 1920s and 1960s. The interviews with Dal Borgo contain an extraordinary wealth of references to the Weltanschauung that invested not

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* This is the research performed in collaboration with Guido Cattani, partly documented in his degree thesis (cf. Cattani (1996) the appendix of which contains a transcription of the interviews).
merely his technical and economic decisions but also the social and, more generally speaking, the relational dimensions in which he was immersed and in which those decisions were taken: all this is described by Dal Borgo with the detachment of one who has lucidly reflected on those events over the subsequent forty years during which he took a personal part in several of the changes occurring in the world in which he operated. The fact that Dal Borgo has re-elaborated his interpretation of kervit has necessitated a delicate work of comparison of the various available sources of information to delineate the cultural context of the interviewees as they themselves perceive it, through time.

Along this line of research, in the interviews it has been useful to approach several themes via “descriptive”, “structural” and “contrast” questions. The “descriptive” questions ask the interviewees to describe people, artifacts, situations and experiences which they have had directly or observed. Such questions are helpful to our research in contextualizing the interviewees’ personal and professional history inside the firm where they have worked. In these descriptions reference is made to people and artifacts for which it is necessary to specify the attributions assigned them by the interviewees. The description requires temporal and spatial rigour (when, in what order, where). The “structural” questions are more technical than those above and require the interviewees to specify technical and conceptual aspects which enable us to understand the meaning of the terms they use. In general, the structural questions are designed to focus on technical and economic aspects of the artifacts discussed, but also on aspects of the relationships between agents and artifacts which are mentioned in the descriptive part. These questions help to define the identity of the agents and the “attributions” that they assign to themselves, to other agents, and to the artifacts that populate their technical, economic and social space. The “contrast” questions are designed to highlight possible differences in the use of certain conceptual categories or expressions: they help to clarify the meaning of the terms used. That is the meaning of both technical terms, but also of the picture that emerges from the way the interviewee represents the agent and artifact space.

The history of kervit and its inventor, Antonino Dal Borgo, will provide the narrative device to outline how innovation comes about in a local production system, but to understand the kervit story we must first abandon the idea of the inventor who solves each and every problem; he is, rather, somebody who formulates and solves problems which are compatible with
his expertise and ideas*. This change of perspective is the key to understanding how it is precisely the combination of Dal Borgo's technical expertise and his ideas of the world which determined, both for better and for worse, kervit's development and demise. As soon as we are ready to unfold such a narrative, we are compelled to find an appropriate language to describe the many interacting elements involved in the dynamics of changes with regard to agents, artifact and to the context in which they operate: the narrative that follows will draw on the vocabulary proposed by Lane and Maxfield (1997) and I shall now summarize their contribution focusing my presentation on the notion of generative relationships.

3.2 Generative relationships and innovation: looking for an adequate language

First of all we need to consider that any relationship between agents is made up of a multiplicity of interactions occurring at many levels (for example, personal as well as professional) and via many channels. Lane and Maxfield (1997) define as "generative" those relationships which can induce changes in the way in which those who participate in the relationship see their world and act within it, bringing about innovations which are generally characterized as new entities — such as, for example, new agents or new artifacts or new institutions. In these terms, the analysis put forward by Lane and Maxfield is consistent with the definition of innovation suggested by Schumpeter (1934), with the vision of space of action put forward by Perroux (1961) and with the notion of technological systems proposed by Hughes (1983)†. Lane and Maxfield's original contribution lies in their specifying what constitutes a "generative relationship" and in which ways such relationships can be created.

To outline these elements we must first introduce a major aspect of the analysis proposed by Lane and Maxfield — namely, the importance of the interpretation of the significance that agents ascribe to themselves, to other agents and to artifacts: what Lane and Maxfield call "attributions". The world in which agents operate is defined precisely in terms of their perception of the context in which they act. Within such a world the interactions between agents and between agents and artifacts define the structure of their space of action. Structural change in the agent/artifact space is

* Cf. Hughes (1971) and Carlson (1992).
† See also the works collected in the volumes edited by Bijker, Hughes and Pinch (1987), and by Bijker and Law (1992).
thus mediated by new attributions as to the identity of the agents and the meaning of the artifacts. The identity of an agent is defined by what he does (his function), how he does it and with whom, and for whom (his character). The significance that agents ascribe to themselves, to their products, to their competitors and clients and to all the other actors present in their world determines the possible space in which they act and the way in which they act. The functions performed by the agent define the "zone" of a space whose structure the agent attempts to change. The character of an agent can be specified by the means (agents and artifacts) that the agent mobilizes to achieve the transformation that he is seeking, by the means and non-material resources with which the agent influences other agents and artifacts to achieve the desired mobilization.

The significance an agent gives to an artifact regards, firstly, the use that agents make of the artifact. The identity of an artifact is thus defined by its use, by who uses it and for what purpose together with (or instead of) which other artifacts. For the person designing or producing the artifact its function alone is not a sufficient attribute: he must also consider the way in which the artifact relates to other artifacts which comprise it. This has also to do with attribution of functionality.

Generative relationships are the result of interactions between agents: entire companies, but also between departments or individuals inside or outside those companies. These multi-level interactions between agents and artifacts (both inside and outside the company) do not necessarily mean that the result will be the creation of a generative relationship or its maintenance: it may be that within a firm there are departments which in their interactions with other agents and artifacts promote the formation of generative relationships while other departments stifle that formation.

This is why the changes which result from generative relationships cannot be predicted on the basis of the type of knowledge possessed by the agents involved in the relationship. Such changes are in fact the result of a process in which the technical, economic, social and institutional dimension are components which do not operate independently of one another. The interpretation of the result of this process thus requires a knowledge of the structure and the history of the interactions which make up the relationships between those agents: since we need a description of the

* This clarifies the sense in which an existing product can be considered an innovation, as Schumpeter, for example, asserted.

† This point is fully discussed by Lane et al. (1996).
The dynamics of interactions, the ethnographic method will provide the most suitable way of acquiring that knowledge.

What makes generative relationships important for our analysis is that they induce changes in attributions, and these changes, which are frequently of a cumulative nature, in turn create conditions for new generative relationships. This boot-strap dynamics is a major feature therefore of the structural change that takes place in agent and artifact space. In order to assess which relationships have generative potential, Lane and Maxfield identify five preconditions.

1. For the transformation of some particular zone of the space, those involved in the relationship must share, in their activities, a focus on some artifact or agent (aligned directedness);

2. The relationship must combine differences between the agents in terms of expertise, attributions or access to particular agents or artifacts (heterogeneity of agents). This can help to generate new expertise or attributions as a result of the relationship.

3. Agents must seek to develop a recurrent pattern of interactions from which a relationship can emerge (mutual directedness). Their willingness to do so depends on the attributions that each assigns to the identity of the other. In this context, mutual trust helps but is not a precondition. Actually, it may be the result of the interactions through which agents realize that they can derive benefits from the relationship that is being generated.

4. It is necessarily for those involved in the relationship to have discursive relationships (permissions). This must also happen outside the conventional exchanges which are generally confined to requests, orders, declarations. This condition is fostered by a company structure which envisages a distributed control.

5. Discussing matters of common interest can prove more incisive if the agents have the chance to interact in at least one activity which sees them working together (opportunity for common action).

Lane and Maxfield stress the fact that these conditions must be constantly monitored because the agents must be in a position to interpret the changes that are the direct result of those relationships. Monitoring can suggest ways of nurturing and maintaining generative potential of relationships, because as soon as an agent discovers that changes are occurring, over a period of time, in respect of attributions (assigned to himself and to
other agents and artifacts), he will also try to identify the source of these changes in the various relationships he is involved in and may also discover a way of feeding those relationships which will possibly give rise, in turn, to further changes.

The notion of generative relationships was introduced by Lane and Maxfield to analyze complex situations, where continual and rapid changes take place in agent and artifact space. In this study, I shall make use of that notion because it provides an adequate language to describe the dynamics of innovation. In particular, I propose to investigate the five conditions which are a feature of generativeness in relationships in order to assess their efficiency in creating changes in agent and artifact attributes, in new relationships with other agents, and in common action to create changes in the agent and artifact space. This approach to the kervit story will enable us to recognize how it first emerged and why it came to grief.

4 THE KERVIT STORY: THE EMERGENCE GENERATIVE RELATIONSHIPS

Let us focus now on the main aspects characterizing the dynamics of changes in the agent and artifact space in which kervit emerged. In particular, kervit’s inventor, Antonino Dal Borgo, and the interplay of changes in his attribution to other agents and artifacts will be presented in section 4.1, highlighting the technical, economic and social characteristics of kervit; section 4.2 then investigates the elements of heterogeneity, aligned and mutual directedness, right permissions and opportunity for common action that were crucial for the generativeness of the relationships – between technical genius Dal Borgo and Maurizio Korach, an intellectual with a wide range of relationships and a leading figure in chemistry – up to the peak of the many licences for kervit issued to dozens of overseas companies in the early 1960s.

4.1 Technical, economic and social characteristics of kervit innovation

When in January 1928 Antonino Dal Borgo arrived at Sant’ Antonino – an unknown backwater on the left bank of the river Secchia, in the Italian province of Reggio Emilia – the Industria Ceramica Veggia S.A. had been operational for no more than four years. With little less than one hundred employees, it was flanked by two other tile factories, originally part of the
Rubbiani firm, which had been in business for more than two centuries. He was called in by Ceramica Veggia to replace the factory foreman—a young chemist who, like himself, had studied at the Scuola d'Arte Ceramica in Faenza—no doubt qualified from the technical point of view, but not up to the task of co-ordinating and supervising the workforce. After only six months, the twenty-two year old was already making a name for himself when he introduced his first ceramic production innovation by substituting the age-old tradition tin glazes, then become expensive, with arsenic glazes. Just after graduation, Dal Borgo had gained work experience in a company in Ferrara and it was probably here that he learned that a chemist from Forlì had tried to use arsenic instead of tin. Following a brief series of experiments conducted in his small laboratory at Veggia, Dal Borgo began producing arsenic glazes, obtaining from the frit a white opaque product at a cost considerably lower than that of the tin glaze*, and this at a time when the glaze was the principle element of production cost. When in the Thirties he used zircon instead of arsenic, he created the glaze that became known as “Sassuolo white”: a glaze, used for many years in Italian tile production, which made it possible to obtain, at low cost, a tile with a white surface applied to the red tiles made of the local clays†.

From Dal Borgo's description of the way in which he discovered these new glazes it emerged that in some cases he simply applied existing techniques in new fields (the properties of arsenic or zirconium), in other cases he found solutions by breaking down the problem into its chemical components‡ and by exploiting the chemical and physical properties of the various compounds. The experimental conditions offered by the small chemistry laboratory he had at the factory were adequate; he availed himself of an assistant's help and—using rudimentary equipment for experimenting and measuring—he did everything himself. He was very young, and the expertise acquired at the Faenza school of ceramic technology could be used to experiment directly and create new things.§

* "In the molten state, the frit spontaneously forms white crystals (lead arsenate) in the glass, thus replacing the tin oxide, which acted as a covering, and costing less. The idea was prompted by the fact that tin oxide was very expensive and difficult to get hold of." [1DB20]; "unlike arsenic, tin has always been a rare and costly commodity, and at that time tin oxide was used only in cold glazing." [1DB21].
† Cf. 2DB35.
‡ As when, in the 1960s, he invented «anticoagulants». Cf. 2DB32.
§ A propos of the sources from which he drew technical information and updates, Dal Borgo cites chemistry books, specialist journals and technical profiles of various Montecatini products, at that time the leading Italian company in the chemical industry.
This innovative spirit is the hallmark of everything Dal Borgo did. However, his innovative approach significantly diverged from that of many other chemists who, in the 1960s and in the 1970s, were to enter ceramics companies in Sassuolo and who developed new colours and surface glazing effects, at times drawing inspiration from production defects in order to obtain original decorative effects. In Dal Borgo’s case, he developed not so much a surface glazing effect, as a new production method – called “vitral” – by means of which the tile, instead of being a biscuit body with a vitrified surface, becomes simply the vitrified layer only a few millimetres thick.

In the case of first vitral, and later kervit, Dal Borgo’s idea stemmed from the combination of two spheres regarding, respectively, the production and the use of the ceramic wall tiles. With regard to the production sphere, Dal Borgo had to face what, at that time, was a common defect in tile production: the “scaling” which formed when the vitrified part came away from the biscuit body. The defective tiles were wasted and this increased production cost. This defect was due to the different dilatation coefficients of the glaze and the biscuit body it was applied to. With regard to the use of the tiles, Dal Borgo observed that, once fixed on a wall, the ceramic tile presented a smooth, easily washable and therefore hygienic, as well as aesthetically pleasing, surface. By focusing only on what he interpreted as the most relevant functionality of the tile, and not so much on improvements on the traditional production technique, he then created the technical conditions which made it possible to achieve the scaling effect over the entire surface of the tile, and in a systematically controlled way, thus obtaining a tile that was little more than a vitrified layer.

* He patented many of his inventions, the most recent, patented at over ninety years of age, was a hearing aid, whose prototype he is using to his own personal satisfaction.
† Until the mid-1960s, the technical management of many ceramics firms was largely under the guidance of a chemist who was often the factory manager as well, widely thought of as a “hands on” figure, up to his elbows in glazes and newly invented paints. The practice of buying in glazes and paints from specialist producers is relatively recent. All ceramics firms produced glazes in house, and during a technical development phase in which a large proportion of processes were carried out manually, glaze production was the most technically complex part and required specific training acquired partly in vocational and technical schools and partly from working alongside the factory chemist as an apprentice or assistant. Cf. Russo (1996).
‡ This name was composed from the first four letters of the Latin word for glass (vitrum). The ending (al) added a touch of modernity coming, already in the 1930s, from the English-speaking world.
¶ It is observable in the history of many inventions that the intersection of two different planes marks a decisive step in the process which produces new entities. For a telling analysis of this process see Koestler (1964).
To obtain this technical condition, Dal Borgo concentrated on the properties of the glazes and of an anti-adhesive (composed of 15% bentonite and 85% magnesite*) which was applied to the surface of a refractory plate whose surface area was that of the tile he wished to produce†. A layer of glaze was then poured onto the anti-adhesive. Decorations were then applied, using stencils obtained by cutting up pieces of greaseproofed paper, as was the traditional practice in the production of majolica tiles. Only at the end of firing did the anti-adhesive react, causing the vitrified face to come away from the refractory plate, which was then used again in further production.

This technique to produce vitrál, which Dal Borgo patented in the spring of 1935, was thus based on a radical change in the molding procedure, using pouring rather than pressing. Pouring is, incidentally, a well-known technique in ceramics – one need only recall that sanitary furniture is produced in this way. The difference is that in the vitral technique the mold used in the pouring stage was no more than a refractory plate. The pouring technique generally makes use of chalk molds for their capacity to absorb the humidity of the preparation poured into them, but chalk would not have been suitable for the vitral procedure since it would not have been usable during the firing phase. This is why Dal Borgo developed the system using a refractory cordierite plate which would be both porous (and hence able to absorb the humidity of the preparation poured onto it) and also resistant to the thermal shock involved in the use of several firing cycles‡. These plates, used in about 100 production cycles§, were pro-

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* Dal Borgo obtained this product by experimenting for about a ten day period. He knew the properties of the materials: a plastifier (bentonite), a refractory (magnesite, a dolomite easily located in the area since the stone is typical of the river Secchia). He knew he had to use only small quantities [1DB25 and note]. During the 1930s, scientific work on the characteristics of bentonite was very confused and imprecise (cf. Vecchi, 1952, p. 19). Employment of this clay, then, was certainly an element developed in an original way by Dal Borgo.

† The anti-adhesive – applied with a spray gun (a very thin layer was sufficient) – was absorbed by the refractory plate. [1DB41]

‡ Cordierite is a silicon aluminate of magnesium. In the early 1950s there was much animated scientific argument as to the employment of cordierite mixtures in industry. Although it had been tried in Italy in the mid-nineteenth century, Vecchi (1952, pp. 21–2) also recalls that in the 1930s Maurizio Korach and G. Fuschi developed the use of cordierite mixtures in order to improve resistance to the sudden temperature changes of electrical insulators. This use (covered by patents of 1932, 1933 and 1937) was also put forward by Korach at various meetings and in a 1934 article in the journal Eletrotecnica. Hence, in the 1930s, its other industrial use seems to have been that made by Dal Borgo who, once again, anticipated the scientific debate that was to develop at the end of the 1940s. The link between Dal Borgo and Korach, of which we will speak later on, suggests that Dal Borgo knew about the research done by Korach and Fuschi; nonetheless Dal Borgo made original use of cordierite mixtures in the production of supporting plates used to produce vitral and, later, kermit tiles.

§ Cf. 1DB37.
duced — inside the firm — using filter-presses for drying, friction presses for molding and small intermittent muffle kilns for firing. Thus a batch of plates was produced each time it was necessary to refurbish the stock depleted by use.

The vitral idea was decidedly innovative and the patent added much to Dal Borgo’s growing reputation as an inventor. However, the originality of the new technique met a serious setback when the materials were first positioned: the use of mortar-based products caused the tile to come away from the wall; a problem which also arose in the case of other new products used in those years for cladding, for example Opaline, large, long opal glass plates 6–7 millimetres thick used as a wall covering in bathrooms. While cladding materials agents welcomed the vitral innovation, those who had to put it in place, i.e. the tile fixers, were not quite so keen.

Alongside the traditional technique of tile production, over the centuries a laying technique had been developed using materials suitable for fixing to the wall a tile consisting of a robust body that “supported” the glazed part. Dal Borgo thought the development of a material more suitable for fixing vitral a secondary consideration, preferring instead to work on a technical solution which would modify the product itself. Side by side with the traditional production of majolica, Dal Borgo thus continued his experiments to solve the problems regarding vitral, and after more than ten years of experimentation he proposed a new idea — kervit — which kept faith with his original idea in terms of the functional features of the tile and in terms of molding by pouring, but he added a biscuit body for the vitrified part.

The kervit technology envisaged applying to the refractory plate, in sequence: first, the anti-adhesive layer; second, a mixture of ceramic preparation some three millimetres thick (which would form the body, as it was called, after firing); third, a layer of engobe and, finally, a layer of glaze. At the end of the firing cycle the refractory plate came away and the kervit tile had more body than vitral. It is worth noting that in ceramics technology the white clay referred to as engobe had been known since antiquity and was used to cover the coloured surface of bowls and drinking vessels. It was Dal Borgo who was the first to use engobe in the production of tiles.

* Cf. 1DB30.
† Cf. 1DB67.
‡ Cf. 1DB31–33. It is worth remembering that in the 1930s the chemical industry had not yet developed synthetic glues, which were not introduced until the 1950s.
since it enabled him to use ordinary materials for the body (as for example discarded tiles or glass fragments which came from Murano). Without the engòbe – to keep the glaze white – it would have been necessary to use pure raw materials which were expensive.

While molding by pouring was a key change in the kervit innovation, the other innovative dimension in the kervit case-history is clearly the single firing of the biscuit support and glaze: one of the main ingredients of subsequent single-fire technology. In the case of vitral and, later, that of ker-vit, Dal Borgo relied on firing techniques used for glazed majolica tiles which were then fired at maximum temperatures of between 960 and 980 degrees centigrade. To achieve the required resistance in the body at these temperatures, Dal Borgo employed vitreous based clay preparations. However, he used a firing time of around two and a half hours, thus much shorter than that then used in firing majolica tiles: this was technically possible and led to a marked reduction in production costs. Reduced firing time was a considerable new departure from techniques then in use: in a tubular kiln ("a passo di pellegrino"), which was then the fastest, firing time was never less than eight hours, while in the tunnel kiln which was subsequently used, firing glazed tiles required around sixteen hours. In another kind of kiln, where saggars of glazed tiles were transported on sliding batts, firing time was initially around twelve hours and, though eventually reduced to five or six hours, were much longer than those used in firing by kervit. In interviews, Dal Borgo stresses that firing time in majolica tile production was fixated by convention rather than by technical demands. The change he introduced was not the result of specific experimentation but rather the "natural" result of what he had theretofore intended: he was using theoretical knowledge and experience which he had probably never even verbalized, but which were implicitly present in his mental apparatus. This knowledge emerged when he concentrated his attention on the specific firing technique to be used for a product which differed from traditional products. At this point he discovered that a firing time of no more than two and a half hours was sufficient, where "discov-

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* Cf. 1DB36. The engobe was subsequently used in the single-fire process.
† Cf. 1DB121.
‡ Cf. 1DB37.
¶ Cf. 1DB63.
§ Referring to how he obtained this result, Dal Borgo replies that "it's one of those things that just happens like the way wheat grows" [Cf. 1DB63 and note] precisely because, with hindsight, discoveries seem obvious.
"ery" means "revealing something that has always been there, but which was hidden from our eyes by the blinkers of habit".

The technical literature of the time describes the kervit technology as technically and economically superior to the technique then in use: introduction of glass in the ceramic mixture provided better cohesion between mixture and glazes; the length of the entire line was only 170 metres as against the 250 of traditional majolica and 300 of terraglia production; the manufacturing process was simple and almost completely automatic. All of this enabled a lower cost as compared with majolica and terraglia (Vecchi, 1952, p. 22). As early as the 1950s, kervit worked out economically competitive. Suffice it to mention that, since kervit production costs were lower than those of majolica tiles, Dal Borgo had decided to sell it at a price which was proportionately lower, aiming at competitiveness based on price which would at all events have covered the cost of the licence (about 5% of turnover) of licensed kervit producers.

All this is confirmed by our research, except for two elements – the simplicity of the process and its level of automation, which were to be critical in the development of kervit, but before discussing these elements in the following sections let us complete the setting of the stage by allowing Maurizio Korach to enter the scene.

4.2 A window on the outside world: Maurizio Korach enters the scene

To develop the kervit procedure, Dal Borgo employed some of his sons as assistants, as well as resorting to the mechanical and woodworking skills of those who worked in the Veggia workshops. This meant a nucleus of around 25 carpenters and mechanics who helped in constructing the machinery and equipment necessary for production.

To this in-house staff must be added the collaboration of Dal Borgo with Maurizio Korach, a leading figure in chemical engineering, but also inter-

* Cf. Koestler (1964), p. 98. When in the early 1960s Dal Borgo worked as a consultant for the firm which had taken over Veggia, he used the experience he had gained with kervit by personally contributing to the production of the first single-fire wall tiles. But, though there are several key features which suggest continuity with kervit, the developments in this production technique, which from the 1980s on has become the most widespread in the district, are also linked to other innovative contexts. For an analysis of the technical and economic conditions in which single-firing developed see Russo (1996).

† Cf. interview with Lusuardi.

‡ The biographical information about Maurizio Korach was collected during the interviews with Dal Borgo, and in the papers by Vecchi (1952), Biavati (1976), Polinszky (1976), Vecchi (1988). Autobiographical notes can be found in Korach (1964).
nationally prestigious in the field of literature. Born in 1888 in Miskolc (Hungary), into a Jewish family of Hungarian extraction, Maurus Korach got his degree in chemical engineering in 1911 at the Polytechnic of Budapest, under the supervision of Vincent Wartha, who was deeply learned in ceramic technology. In order to avoid the oath of loyalty to the Austro-Hungarian monarchy, in 1912 he fled to Italy, where, thanks to his excellent technical culture, he became assistant to Professor Panebianco, teacher of Merceology at the University of Padua. In 1914 he was summoned by Gaetano Ballardini, then director of the Scuola d'Arte Ceramica recently set up at Faenza, and together they embarked on a successful collaboration*. On the outbreak of the First World War Korach volunteered for service in the Italian army and took citizenship, but he was stationed behind the lines and there met Riccardo Bacchelli, with whom he subsequently cooperated in the antifascist literary periodical La Ronda†. In the 1920s he directed the Experimental Ceramics Laboratory at Faenza and taught at the Scuola d'Arte. He left this job at Faenza in 1929–30 when he became privadozent in Chemical Engineering Equipment and Machines at the University of Bologna. Only a few years later, he left off teaching in order to escape persecution by the fascists‡. Changing his name to Mar-

* At the Esposizione Toscelliana in Faenza, 1908, Ballardini had admired the "polished" products of the Hungarian factory at Zolnay, of which Wartha was consultant; at that time Wartha was considered the leading world expert in ceramic chemistry. This was therefore an important opportunity for Ballardini to involve Korach, Wartha's pupil ("the wizard of Budapest" as Korach calls Wartha) in the projects concerning the art school that had just been set up (cf. Korach, 1964, and Biavati, 1976). Korach (1964) recalls how the collaboration between himself and Ballardini was a happy encounter between the historical-artistic view of production, Ballardini's, and his own technical background. From that encounter, made possible by their common "humanistic ideal", arose the Experimental Chemistry Laboratory of the Scuola d'Arte Ceramica at Faenza that Korach directed for ten years and contributed to making a research centre at international level.

† Cf. Bacchelli (1976). On Korach's contribution to this periodical see the book by Carmine di Biasi, Maurizio Korach (Marcello Cora). La Ronda e la letteratura tedesca, published, with a preface by Bacchelli, by Società editrice napoletana in 1978. Korach's literary contributions had already been noted in a book of 1930 by E. Falqui and E. Vittorini (Scrivitori nuovi, Lanciano, Carabba). Between 1910 and 1975 Korach published more than 200 items of technical-scientific character (see bibliography in Società Italiana della Ceramica, 1976), but no less important was his literary production, consisting of "24 stories, 10 poems in prose, 49 fables, 10 dialogues, a play, 12 polemics, 8 literary essays, two articles of aesthetic popularization, 37 articles on economics and politics, 5 political articles, as well as 28 critiques and reviews and 24 translations" (Polinszky, 1976, p. 13).

‡ Already when he worked in Faenza, his dissent from Fascism was well known enough for the local Fascists to make him drink castor oil at the entrance of the School. Later, when he was in Bologna, he was advised by a friend that fascists were plotting to kill him (cf. 1DB95 and Biavati, 1976).
cello Cora enabled him to continue with his work as consultant to Italian chemical firms until the race laws came into force in 1938, whereupon he decided to leave Italy. He returned to take part in the war of liberation, but was arrested and imprisoned at San Vittore. After the liberation, he resumed his academic activity, but his possibilities in Italy were limited by his connections with support for the Communist Party and his scientific ambitions, so he agreed to cooperate with the Hungarian government in the creation of the Central Institute for Building Materials which, thanks also to his work, was for decades the leading research centre in Europe in this field.*

Korach is important in the kervit story for at least two reasons: firstly with regard to patent activity, secondly concerning the use of the “a passo di pellegrino” kiln (to which we shall make only marginal reference). As he had done previously for the vitral process, Dal Borgo entirely entrusted to his master and friend Maurizio Korach the task of preparing the technical specifications to be included in the kervit patent registration documents. He described in detail the technical procedures he had refined during the long period of experimentation and Korach couched them in the formal language required for a patent application. Since he was heavily engaged in the running of the Veggia factory, Dal Borgo also delegated to Korach the task of publicizing the features of the patented kervit system†. His academic position held before the War together with his fame as brilliant research scientist and intellectual with a wide network of international acquaintances opened up numerous opportunities for Korach to sell the kervit licence abroad. Korach, who was well connected in the university world and frequented writers, painters and intellectuals, was put into contact via Swiss friends with John E. Mackenzie, a Scottish nobleman who taught parapsychology in Geneva and who had a wide network of business relations at an international level. Mackenzie became a key figure in the distribution of the kervit patent in the 1950s. In addition to Switzerland, Germany, France and Great Britain, the kervit licence was also sold in Israel, Venezuela and Brazil. The sole licensee and producer in Italy was Ilsa of Albissola in the province of Savona.

* The invitation came from his sister-in-law, leading figure in the Russian revolution and minister in the first post-war Hungarian government. In 1975, Korach died in Budapest.
† In the previous experience with vitral, it had been Korach who made contact with Swiss, French and Dutch firms in order to sell the vitral licence. In 1955 Korach also published a series of articles in technical journals (in German, Hungarian and French) in which he described the kervit technology (cf. Vecchi, 1952 and 1988; Korach, 1955).
Even after his return to Hungary, Korach remained in contact with Dal Borgo and for several years took part in the international meetings that were held annually to diffuse the improvements introduced by Dal Borgo to the Kervit licensees.

5 THE KERVIT STORY: CRITICAL ASPECTS MARKING ITS DEMISE

The relational aspects are one of the keys to understanding what happened to Kervit and the subsequent turns the history of Veggia was to take. The economic and cultural environment in which Dal Borgo operated since the 1920s was that of an Italian province considered a depressed area from the economic point of view. Agriculture was the chief economic activity and the few industrial companies that operated in the area astride the provinces of Modena and Reggio Emilia on the banks of the river Secchia were a handful of fruit conserve firms, the producer of Sassolino (a liqueur well known in the area) and three other ceramics firms which had set up beside the companies who had been first to arrive in the area. When Kervit was discarded, in the mid-1960s, the social and economic environment had markedly changed: a strong increase in demand of ceramic tiles and a relatively simple technology characterized the surging ceramic tile district that was offering everybody a chance to make handsome earnings from the transformation of clay into tiles. Why was Kervit discarded just when the district was emerging with its incredible high rate of growth and profits?

By telling the story of Veggia's failure, section 5.1 introduces a first answer to this question: Kervit was discarded *inter alia* because the firm that had introduced it failed. We must then give account of the factors weakening the competitive position of the company headed by Dal Borgo, up to its failure. In this section the main focus will be on the description of the innovation dynamics in an environment that has changed because the innovation has initiated a series of changes and also because endogenous changes have affected the agents and artifact space here examined. Section 5.2 argues that the strong hierarchical organizational of Dal Borgo's company certainly contributed to its exclusion from external cross fertilization; section 5.3 presents the peculiar process of collective invention — emerging in the surging ceramic district — from which Dal Borgo kept himself
and his company apart; and, finally, section 5.4 describes the way in which other agents, the press producers, were able to foster new generative relationships which contributed in displacing kervit space.

5.1 The failure of Ceramica Veggia

The long period of experimentation had allowed Dal Borgo to develop a procedure that could be used on an industrial scale and Dal Borgo intended to take advantage of the financial benefits which would result from his invention: in 1947 he patented the kervit process and obtained a new contract with Veggia in order to insert a clause which, apart from recognizing his right to benefit personally from the patent protection, also gave him a minority shareholding in the company. Nine years later Industria Ceramica Veggia dismissed Dal Borgo, accusing him of exploiting for personal gain a patent which, according to legislation then in force, should have belonged to the company of which he was an employee. He made counter claims against the Veggia majority shareholder, since the special clause inserted in the contract would have secured a verdict in his favour. However, the matter never came to court: without his vital technical guidance, within the space of several months the company was on the verge of bankruptcy and, seven months after being dismissed, the old proprietors withdrew the charges and Dal Borgo returned to Veggia in 1957 as Chairman and major shareholder.*

Dal Borgo retained that position until 1967, when the Modena court declared Ceramica Veggia bankrupt, a turning-point in the kerist story.†

While involved in the technical management of the firm, Dal Borgo had engaged in illegal accounting practices, very widespread at that time. Official inspection revealed that a sum of more than 500 million lire was unaccounted for, and Ceramica Veggia was put into receivership. Summoned before the bankruptcy court, Dal Borgo requested a stay of 15 days in

* A third of the shares were acquired by his friends at the Ilsa plant in Albissola in the province of Savona. [Cf. 1DB112]. Albissola was another of the ceramics districts, in addition to those of Vietri, Faenza and Porto Potenza Picena. Dal Borgo met the owners of Ilsa via a mutual friend, a socialist, who managed a shop selling Ilsa pottery in Sassuolo. To flee from political persecution during the war, one of the two brothers who owned Ilsa took refuge in France, whereas the other brother, an ex-navy officer, was taken in with his wife by Dal Borgo at his Sassuolo home. During his six-month stay, a deep friendship, based on reciprocal respect, developed between them, and this helps to explain why he was so ready to finance Dal Borgo in acquiring the Veggia shares.
† Cf. 1DB113±116.
order to give Kervit's British licensees time to weigh up a takeover of Ceramica Veggia, but the request was turned down by the court. Whereupon Dal Borgo — who had no doubts of the firm's technical solidity — appealed and offered to repay the creditors 50% of what they were owed (and in the following year the firm's management did indeed recover an amount exceeding 100% of their loans). The appeal, too, was refused, but the bankruptcy, declared on 21 April 1967, was not paid off till nearly twenty years later, with a mere 10–11% to the creditors. Following the bankruptcy, Ceramica Veggia still went on producing tiles for a year, but soon switched to manufacturing colours, without Dal Borgo.

The bankruptcy was due mainly to bad management, but the economic and administrative elements alone are not enough to explain the vehemence shown by the receivers in this case. To provide a convincing explanation it would be necessary to adduce much fuller documentation relative to the bankruptcy proceedings, as well as conducting a historical analysis of the political and social context of those years. This all lies outside the area of this study. Here I want to point out an aspect of the Veggia closure that takes us into a context widely discussed in economic literature inspired by Schumpeter, where the economic figure of the innovator is seen as analytically distinct from that of the inventor and stress is laid on the importance of the economic aspects of innovative activity. Though authoritative and extremely clever, Dal Borgo found it very difficult to deal with bankruptcy; his technical capabilities — which for forty years had enabled him to manage and then to buy a flourishing firm in continual expansion — suddenly appeared insufficient*. While still remaining an irreplaceable inventor, Dal Borgo failed to become the complete entrepreneur, precisely because he was unable to take account of the multiple changes (including the economic ones) that resulted from his inventions.

* Not that hints of the need to change tack were lacking. Suffice it to think that his sons, close collaborators in the management of the firm, were aware of the need for a management that should add economic consistency to the extraordinary technical capacity of the inventor. That is why they suggested he hire Gianfranco Carnevali, a young engineer with good experience of industrial organization in the metal engineering sector and strongly concerned to remain working at Sassuolo. Carnevali enthusiastically accepted the opportunity to apply his methods of industrial organization to a completely virgin territory; at that time, in the ceramics firms of the district there were only three other engineers, all at Marazzi. But his enthusiasm soon waned before the constant necessity to change the production programmes as they went up in smoke owing to the continual alterations in the glazes suggested and imposed by Dal Borgo. To be sure, these alterations improved the product, but they made programming of the whole production process, and thus fulfillment of the orders, extremely unstable (cf. Carnevali 25).
5.2 Enterprise organization models and social relations

An implication of bad management recalls our attention to Veggia's organizational model that, like other ceramics firms operational at the time, involved a strategy of centralized control. In particular, Dal Borgo centralized to himself all the technical decisions, together with the poor economic control: this gave latitude for opportunistic behaviour at the limits of legality – to the point where Dal Borgo himself was forced to intervene, dismissing 16 workers who had removed materials and equipment belonging to Ceramica Veggia that were subsequently used in other ceramics firms set up by its employees. Aside from these workers, against whom incontestable evidence was brought, there had been other cases in the early 1960s of employees who had profited from Dal Borgo's negligence in day-to-day economic and administrative matters.

These cases of opportunistic behaviour signal a situation with no common vision shared by the workers of Veggia and markedly affected by the absence of right permissions and opportunities for common action. Although Veggia was for a long time an important centre of technical training for hundreds of workers, Dal Borgo had a hierarchical vision of the company's organization that allowed no room for initiatives from any one but himself. His sons – who ran the organizational side of the company – were as rigid as their father in managing social relationships with the company's workers.

Although, at that time, extremely hierarchical and centralized control was a common feature in many other companies, it is interesting to compare Veggia's organizational and relational model with the one prevailing at Marazzi, a ceramics firm that came into being in 1936 in Sassuolo, of size comparable to that of Veggia. Filippo Marazzi, the firm's owner, was an entrepreneur with previous commercial experience on a local scale. Marazzi made up for a lack of specific technical training by taking on young technicians and giving a chance to those with flair and zeal to have a go, tucked away in a corner of the factory, at inventing something of use for the industry. This was the case with Leo Morandi who, during the 1950s, thanks partly to the experience gained with Marazzi, rose from respected bicycle repair man to become one of the most prolific

* Cf. 1DB113 and Carnevali 27+31
† Cf. interview with Lusuardi.
inventors of devices for glazing equipment. The Marazzi microcosm
aspired to being also a model of social and religious integration: witness
the building of an infant school for the children of company employees,
the medical clinic, and even a chapel where mass was celebrated. But
Pietro Marazzi (who had taken over from his father at the head of the
company) also set up a research and development unit inside the factory
which became, from the 1950s on, an important centre for the innovation
process which subsequently spread throughout the district.

Unlike Veggia, Marazzi actively sought interchange with the outside
world. That Veggia did not do so helps to account for the state of isolation
in which Veggia found itself when bankruptcy supervened.

5.3 Small improvements within the firm vs. collective invention
in the local system

The fact that Dal Borgo remained prisoner, so to speak, of his factory, was
a choice initially imposed on him by the lack of opportunities offered by
the environment in which his work attitude had been shaped. In the inter-
views, Dal Borgo justifies his choice as the answer to autarchy imposed by
the fascist regime; autarchy was to become a cultural model vis-à-vis the
outside world, but in Dal Borgo's case it also became the organizational
and economic model at individual company level. And it was inside the
factory that a generation of technicians, mechanics and carpenters was
trained, as well as foremen and department heads who subsequently
became entrepreneurs or plant managers in the ceramics firms (or ceram-

* But in subsequent decades many other firms were set up by former Marazzi employees,
as for example the firm that produced engineer Mario Poppi's kilns, or System, whose owner
Franco Stefani had produced the serigraphic machine at Marazzi and from there went into
business on his own, becoming one of the most dynamic machinery producers in the ceram-
ics industry. Cf. Russo (1996).
† It is as well to remark that, although there are no systematic studies of these events, from
the information I have managed to collect, the paternalistic model adopted by Marazzi seems
no different from that of other large firms that were operating in North Italy, e.g. Falk at Sesto
San Giovanni, Milan (cf. Bertuccelli 1997).
‡ Cf. 2DB7.
§ Although concrete performance of the autarchy plan was modest, it was successful from
an ideological and propaganda point of view, because many technicians and scientists inter-
preted autarchy as the manifestation of a plan for altering society based on the canons of sci-
entific rationality. On this interpretation of autarchy see Maiocchi (1998).
¶ In tile production, all the operations were carried out manually and during the 1950s
Veggia's size grew to as many as 600 workers. Although this fell to some 300 by 1966, Veg-
gia's dimensions were those of a firm with a multi-level hierarchy in terms of the organiza-
tional control of work and factory discipline.
ics machine firms) which in the course of the 1960s sprang up all over the area. Being cloistered away inside the factory was part and parcel of a great innovative project, the vitral and kervit process.

Compared with the traditional production technique used for majolica tiles, what distinguished kervit was essentially the fact that, apart from the molding/pouring procedure, which we shall discuss further below, it needed only one firing during which the thin layer known as body, the layer of engobe and the glaze were thus all fired together. The firing cycle was considerably reduced (by about two and a half hours) in kilns which fired one layer of tiles at a time. Stated briefly in these terms, kervit technology appears analogous with the rapid single-firing technology which was widely adopted in the ceramics district during the 1980s; and to some extent it is, even if marked differences and discontinuities are apparent in the transition from one technology to the other. The interpretation of these discontinuities once again requires that we consider the relational aspects of the case.

* This project was to become a technical model so inbred as not to be recognizable as such even by the technicians who were formed within it. In the hundreds of interviews with technicians and experts on ceramic tile technologies, conducted by me over the last twenty-five years, I never noted a mention of kervit technology. It was first mentioned to me by engineer Franco Carnevali two years ago (and in a detailed way in the interview of October 1998), but not during the several discussions on the development of ceramic technology which we had had in the previous twenty years. I spoke of this technology with a degree student of mine, Guido Cattani, who was conducting interviews on the innovation process in the production of low porosity single-firing tiles. We decided to collect the documentation that we gradually turned up on kervit. From the analysis of the transcriptions (cf. Cattani, 1996), I found four interviews in which kervit was cited: the kervit story resurfaced in the memory of the technicians interviewed when they were referring to a single-fire, low porosity product arriving on the market that was recalled as having the technical properties of the kervit product. All four technicians indicated kervit as a technology that had anticipated the main technical developments thereafter established in the 1980s. And it is no accident that those technicians belonged, like Carnevali, to the generation that had been able directly to interface with the kervit technology (because they had been employees of Ceramica Veggie or competing firms).

† Initially, the tubular kilns used for firing majolica were also used in firing kervit. Some eight metres in length, these had 32 to 48 channels. The mouth of the kiln resembled so many little windows, all of which were channels. The tiles moved forward because one pushed the other. The daily output of a tubular kiln was about 400–500 tiles. In the early 1950s, kilns (known as “a passo di pellegrino”), designed by engineer Drago in collaboration with Korsach and Battistin had a production capacity similar to the tubular kilns. From the late 1950s on, however, Dal Borgo used tunnel kilns that were built by the German firm Kerscher: they used small trolleys (approx. 66x66 cm), on which a single layer of tiles was placed, and their production capacity was around 300 square metres per day [DB56-62]. In the 1960s a similar kiln, with a trolley for single layer firing, was proposed by Poppi for rapid single-firing.
In the course of over twenty years, Dal Borgo developed numerous devices and tools for the keravit production system, but the only one which was widely used, and is still used to day, is what is known as "the bell". As far as traditional twice-fire production is concerned, a process began in the early 1960s whereby moving operations were mechanized, and this process went on for over ten years. These were years in which a process of collective invention emerged. This process was made possible by a continuous flow of information between technicians and production experts, who moved from one firm to another, who were often personally acquainted and who shared in the common adventure of bringing to life Sassuolo’s new ceramics industry.

Veggia, however, seemed excluded from this process: the keravit patent concerned a procedure which was not easy to imitate by introducing alterations so as to circumvent the patent protection, because inter alia employment of the keravit technology relied greatly on the tacit knowledge acquired by Dal Borgo during the long stage of experimentation and production on industrial scale. Moreover, as is the case with many technologies, it was a question of developing complementary technologies, a subject which was due to emerge.

* "At one point it emerged that, with the pouring process, the tile did not come out flat, and this was due to the fact that the tool we were using was the old orifice of the glazing machine which was made of a hopper which had an adjustable aperture at the bottom, which meant that a veil was formed - for the simple reason that pouring was slightly delayed - but in the middle it was slightly raised and overflowed towards the sides. Well, I solved the problem in two ways. First using an instrument, the bell, which they still use today. It was I who invented the bell to solve this very problem. Because, being curved, less went into the middle and more went to the sides. But the problem of the edge remained, so I invented a little device: I applied a disc which acted like a knife and cut away 4 to 5 millimetres from a tile 15x15 cm or 20x20 cm, from each side in such a way that the tile was trimmed straight at the edges." [1DB 44].

But the production of formats such as the mosaic also made it necessary to develop suitable tools. "The formats were basically 15x15 and 10,8x10,8 cm (4x4 inches, the American format); then when I set to thinking about the mosaic, I began producing 20x20 cm (it was clearly a little larger because the edges were later trimmed). The idea of the mosaic occurred to me like this: how do you cut glass? If you cut glass you use a diamond which makes a mark you then break. So I had this idea: I fitted very thin discs which had extremely sharp blades and were supported by springs strong enough to exert the required pressure to make a diamond incision in the unfired tile. These discs were positioned on the glazing line, and were stood on points so they could be dragged along: the tile passed by and the incision was made, that is, the line was traced in it". [1DB 49]. When firing was over, the various pieces that made up the mosaic were broken off.

The belts themselves also needed to be modified. In particular: "the belts on which the material was transported along the pouring and glazing lines easily got dirty and I had nails inserted in them to hold the tiles up higher" [1DB 104].

† The notion of collective invention is discussed by Robert Allen (1983). In a situation where the majority of firms did not allocate resources to research and development, collective invention was an efficient innovation process even for the individual firm.

‡ "Patents covered the entire method and procedure throughout its development, nobody could have copied the technology, the invention was protected" [1DB122].
requirement which was to an extent amply fulfilled by Dal Borgo's personal qualities, since he personally led the group of mechanics and carpenters working under him at Veggia. Nevertheless, the spread of automatic devices for moving operations in the traditional production process represented a challenge, both technical and economic, to which Veggia was unable to respond: the technical insularity which had developed inside the factory precluded the possibility of exchange with the outside world, and this acted against the interests of the kervit system.

In the early 1960s, the technical and economic — not to mention social — environment had come a long way from the days when the kervit system was developed. There were now numerous firms producing majolica tiles which were a source of growing demand for specific mechanical innovations, not simply kervit adaptations. And this is one of the factors — the other being the difficulty of imitating the process — which explains the oblivion into which kervit fell following the closure of the Veggia plant. Oblivion here means that kervit technology was no longer adopted, but — as a result of Dal Borgo's self-exclusion from the process of collective invention — the knowledge necessary to foster the many activities developing in the booming ceramic district did indeed emerge. In fact, Veggia's failure freed human resources endowed with excellent technical training acquired in the long experience in kervit production. More open than Dal Borgo to the new social and technical opportunities emerging in the changed environment, many of the Veggia's ex-workers were in fact very active in starting up new independent enterprises, as producers both of tiles and of ceramics machinery.

5.4 Innovation, complementary activities and industrial dynamics

The kervit experience left its mark precisely because it trained a vast quantity of technicians, but also because it was a model of technical innovation which was decidedly different from anything else in the district, as is witnessed by the radical technical alternatives it introduced in molding and firing, two vital areas of the production process. In particular, molding via pouring as used in the kervit system ran radically counter to the technical and economic interests of the press manufacturers * and the investigation

* Kervit production certainly did not sweep away press production because, at all events, it continued to use refractory plates, the mold onto which the preparation was poured, which were produced by a molding process using a press. Every plate was used in 80 or 100 production cycles and thus the potential development of press production would have been reduced to one hundredth.
of this aspect highlights some important links between innovation, the emergence of complementary activities and industrial dynamics.

First of all, we should note that in the 1930s, when vitral was being developed, the two molding processes – pouring and pressing – both had the same degree of mechanization*. Molding by pouring increased the use of the glazing line: a piece of equipment consisting of a metal frame which supported the belt on which the tiles passed between one application and another. In molding by the use of presses, both the filling of the molds and the activation of the head which compressed the clay were done manually, and presses had therefore a limited capacity, producing only small format tiles.

During the twenty years that saw the development of kervit, the refinement of the various machines involved in the pouring and glazing line resulted in higher product quality but did not substantially change the production capacity of that line, nor the degree of automation in the loading and unloading of the line, which was still done manually. Press production, on the contrary, underwent considerable transformation, leading to the development of powerful friction presses, which in the early 1960s were completely automatic. The increase in the level of mechanization had increased potential in terms of the capacity to press tiles larger in format than those available through the use of manual presses and, above all, it had increased production capacity, by thus requiring the development of semi-automatic and automatic devices for the extraction of pressed material and for loading the trolleys†.

The presses had always been produced by specialist firms, and by the end of the 1950s several Italian producers were making important headway in foreign markets, outstripping even the Germans, the original European market leaders. This was all thanks to production expansion within the Sassuolo district: Ceppelli (in Sassuolo), Welko (whose head office was in Milan but which manufactured in Sassuolo) and Sacmi (of Imola). These firms were much larger than other machinery producers with a product far more complex in terms of the components and the technical expertise required to manufacture them. The press producers initiated a lot of the

* The notion of mechanization level referred to in the text is that developed by Bright (1958).
† The increase in press production capacity showed up the inefficiency of manual performance of manual unloading of the materials because a larger number of workers would have been necessary for each press, and this was practically impossible owing to the physical space available at the end of the press.
innovations related to the movement of material in various phases of the manufacturing process which they developed during the early 1960s as techniques complementary to pressing; and these innovations were produced either in house or by small engineering sub-suppliers from the district.

The search for solutions to various technical imbalances* between the many operations connected with the pressing phase was then a key opportunity seized upon by press producers to activate the all-important information exchange mechanism — with tile and components manufacturers — which was conspicuous by its absence from the ker vit environment.

6 CONCLUSIONS: AN INTERPRETATION BASED ON THE CONCEPT OF GENERATIVE RELATIONSHIPS

Section 5 has highlighted some critical elements characterizing ker vit's demise, one might say: looking at actors initiating the changes in the agent/artifact space in which ker vit emerged. But it still remains to explain why no other company in the district decided to buy the ker vit licence and produce with ker vit technology after the closure of Veggia; and why the process of imitation that has been so fundamental a factor in the spread of many techniques in the ceramics district did not occur in this case.

A recurrent reply to this question — which is echoed in some of the interviews with ceramics experts† — is that the main reason for abandoning ker vit technology was the increase in labour costs during the 1960s. But the ethnographic analysis has allowed us to reconstruct the dynamics of the ker vit innovation process, showing that the economic assessment remains generally valid but is insufficient to explain why ker vit was abandoned. My interpretation of the ker vit story highlights that other elements have played a major role in the innovation dynamics — i.e. the need to monitor and fuel the generative potential of relations in agents' and artifacts' space. It is within this framework that the ker vit system remained unaffected by the process of collective invention, and the emergence of complementary activities was not exploited with the potentialities that other actors were

* The role of technical disequilibrium between the components of a machine and of a process is highlighted by Rosenberg (1969) as being an important device in focusing innovative activity.
† Cf. Cattani (1997).
able to recognize. I should therefore like to conclude by focusing attention on three main issues around which to sum up this interpretation.

6.1 Monitoring and fostering generative relationships: the missing conditions

When Dal Borgo explains his decision to patent the procedures and devices he had invented, he highlights two basic reasons. The first is personal pride — the pleasure of being recognized as an inventor*. The second is a strictly economic reason. Dal Borgo believed that the patent would guarantee financial gain from the invention. And yet he did not deal directly with the matter since this required relational skills and international connections. Dal Borgo delegated this side to Korach, who was well connected in a variety of settings. Until the mid-1950s, in the relationship between Dal Borgo and Korach there were all the five conditions necessary to describe that relationship as generative of changes in the space in which they operated. However, though both acted in an aligned directedness (increasing kervit sales in the world market), differences in expertise and fields of activity that had positively marked the two actors' heterogeneity became a disadvantage because there was no longer mutual directedness. Korach, who took care of the commercial aspects of overseas licence sales, did not mobilize the technical and production linkages which might have been able to generate the development of kervit-related complementary techniques — not just movement operations and firing techniques, but also technologies and materials for fixing kervit tiles.

At the beginning of his career as inventor in the 1930s and later as entrepreneur in the 1950s, Dal Borgo used his own technical ability to build around him a technology which was difficult to imitate and of which he intended to remain the sole user. From the supply side, there were few other companies which produced wall tiles using traditional production

* Although the technical and scientific community recognized his original contribution as the author of kervit (cf. Vecchi, 1952; Korach, 1955), in the local community Korach's fame was predominant. In this respect, it must have been very galling to acknowledge over the years that the pleasure of being recognized as kervit inventor was denied him because he wanted to share the patent with his friend and master Maurizio Korach.

In the first interview, Dal Borgo recalled that at the end of the war, Korach came into contact with the Reggio Emilia federation of the Communist Party. It was in this environment that the rumour spread that Korach was the true inventor of the kervit system, a misconception abetted by the fact that Korach, apart from his fame as an intellectual, was involved in preparing the patent registration documents and in selling the licence. Dal Borgo asked him to publish a denial in the local communist party magazine, but the article had little effect.
techniques and sold mainly to the Italian market. At the end of the 1950s, changes on the demand side brought about the growth of numerous firms which were soon to face the 1963–64 slump: dozens of firms closed, but those which managed to weather the storm gained momentum in the wake of the introduction of the tunnel kiln, high-output presses and the dramatic expansion in demand for floor tiles. In the 1960s, the economic and social climate was radically different from that in which Dal Borgo had started developing the kervit technology: alongside the hundreds of firms producing tiles there were now numerous manufacturers of specialist machinery and equipment. Though other ceramics firms also produced in-house some machinery used in the production process, the fact that, throughout the 1960s, Veggia continued to produce in-house all of the kervit specific equipment was certainly an exceptional situation. But this was no longer a choice vis-à-vis an environment which did not offer technical opportunities; rather, it was Dal Borgo who did not take account of changes which had taken place in the environment in which he was operating: he had always wanted to work alone and he thought he could continue doing so, without links with other technicians.

Some critical elements characterizing generative relationships were lacking. In particular, Dal Borgo no longer looked for interactions with heterogeneous agents, though in the past these had had such an important effect on his innovations. In the interviews he is quite clear on this point: according to him there were no other technicians in the firm with whom he could interface*. Nor did he seek contacts with outside: like every artisan, he felt himself to be in possession of a fundamental secret for “making a finer, less expensive product”. This view hindered him from taking up organizational hints even though they came from within the factory; and, basically, even the periodic meetings with kervit licensees acted as a means of transmitting to them the solutions he had adopted, but were never used to focus upon a joint initiative to bring about changes in kervit’s position vis-à-vis other, rival products. His overriding technical genius and his fixed view of ceramic production as artisanal production prevented him from understanding that exchange of his with others' experiences might be fruitful. His centralization of technical decisions and authoritarian single-mindedness left others no time and space to talk, nor freedom of action in the common interest of Veggia (i.e. no right permissions). When agents interact, all these are essential conditions facilitating their understanding of their respective expertise and identity. And the possibilities which

* Cf. 1DB69+70 and footnote, cf. also interviews with Lusuardi and Carnevali.
emerge from their joint activities will be enhanced when their relationships are interwoven with a network of other relationships (Lane and Maxfield, 1997). The absence of right permissions had a negative effect on Dal Borgo's understanding of ongoing changes and helped to alienate him from the control of the technical and economic space he himself had created.

6.2 Technical and social dimension of the imitation process: collective invention and the emergence of new competences

What emerges from the kervit story is not only that kervit made it possible to manufacture a wall tile that was difficult to produce, but also that it was hard to come up with anything similar, that is, inventing around the cover offered by patent protection. The difficulty in using this production method lay in the considerable variability of the technical parameters – owing to the use of natural raw materials whose composition varied – which were subject to a transformation process in which environmental parameters (temperature and humidity) significantly alter the outcome of the process. The adjustments needed to achieve good results (in terms of a low reject percentage and uniform product quality) required a practical knowledge that could be acquired only with a great deal of production experience. Although this tacit knowledge could certainly help explain why kervit was abandoned, this explanation is not enough for other techniques had similar problems in subsequent years, but were not abandoned. In the case of kervit technology, we come nearer to an explanation if we also consider the technical and social isolation at Veggia: it is in this context that considerations of cost and an assessment of the massive necessity of tacit knowledge (to overcome technical difficulties) appear relevant.

Kervit's isolation was actually worsened by *inter alia* the impossibility of imitating it. From the kervit case history (but a similar case is that of Enduro technology patented by Marazzi in the mid-1980s) it would appear that imitation is a crucial factor for the success of an innovation: "many actors win, one alone loses". Even a far-reaching innovation cannot manage to assert itself if the monopoly position of its inventor proves a condition of weakness when the other producers are able to form an alliance against the monopolist, discrediting the reputed superiority of the proposed innovation. Moreover, potential users perceive the fact that there is only one supplier of the innovative product as a sign that "something must
be wrong, otherwise the others would have done it". These two factors, which were to kervit's disadvantage, help to describe the technical and social isolation in which this technology found itself as compared with other alternatives that emerged in the 1960s.

The twenty years during which kervit production took place on an industrial scale have nevertheless left a legacy of knowledge which permeates the entire local production system. This is not only because Veggie trained large numbers of technicians, not only because kervit technology contained the essential ingredients for the technical development of the following forty years, but also because it actually provided an economic model to be avoided.

To appreciate this point, let us consider, for example, a different case which occurred in the 1970s, when Marazzi developed a single-fire production process which featured the use of a roller kiln. At first the technicians working on the new kiln were quarantined at the Fornovo pilot factory, far from the ceramics district and, when ready, the kiln was patented. Then, Filippo Marazzi threw open the doors of the Sassuolo factory (in which the new kiln was installed) to whoever wanted to see what was going on. It was not patenting the process, but its maximum accessibility which became the necessary condition for taking full economic advantage of the innovation. For it is through imitation that conditions may be created for the development of complementary techniques.

This imitative process does not involve all agents globally – rather, it is a local process: you only imitate what is being done by your "neighbour". Proximity, here, is defined in spatial terms (you have to see it with your own eyes), but also in technical terms (you have to have similar skills to those of the person you are imitating), and relational terms. The latter means that the particular interaction in which observation of the artifact or of the process used by another agent takes place is made possible by the fact that between those agents there are other interactions on the personal and economic level. The general result of this imitation process is a repositioning of the overall system. This takes place because to imitate it is necessary to have similar skills, but agents are not identical and the imitator has specific competences and specific relationships with agents and artifacts. Such relationships can trigger new entities (new agents or artifacts), but also new competences: this is the outcome of the imitation process that

* Similar considerations apply to many others filed (a well known case is the Macintosh story).
has characterized the innovation dynamics and the industrial dynamics in the ceramic tile district.

6.3 The social dimension of patents and dynamic complementarities

Dal Borgo, who only dealt with technical and operative matters, assessed the impact of endogenous change in demand on the economic environment in which he operated as secondary for his own activity. Other agents, however, saw those changes as the opportunity to modify the space relevant to their action, albeit within the limits of their technical ability. It was precisely these limits which guided the choice towards developing techniques easier to use than those in the kervit system but decidedly more remunerative in terms of the profits they were to make possible.

We have seen in the case of kervit that patenting the production method can considerably influence the potential spread of the technology involved, but it might be objected that, basically, this story also clearly involves a question of scale. If kervit production had been not a thousand but fifty thousand square metres a day, then it might well have necessitated the development of complementary techniques inside the firm or on the part of outside specialist producers. And this is one of the reasons why it does not seem opportune to consider patents as a reliable indicator of innovations achieved within a small business production system: the individual firm is not big enough to develop in house all the complementary technologies which prove indispensable if its full potential is to be exploited, and neither does it always prove possible to find solutions to technical problems arising out of the use of a new technology. In such a context, by limiting the circulation of technical information, the patent does not therefore offer the chance of interaction between agents and artifacts which could bring about the changes (new artifacts, new agents and new entities) required for the development of new technology.

The importance of links with the outside world has been recognized as a crucial factor for the success of an innovation since Carter and Williams published their studies in the late 1950s†. However, what has emerged from our research is that the key factor is not what is usually highlighted in

* An economic assessment of the techniques in use in the 1960s has shown that ceramics firms have achieved profits as high as 200%. (See the degree theses of Ezio Cervi and Gabrielle Canetti, Faculty of Economics and Commerce, Modena, 1972–73).
† Cf. Carter and Williams (1959).
such studies, i.e. the link with the scientific world of the particular field in which the innovation is developed; the key factor is the links which should have been created with the network of potential innovators of all the complementary technologies. It was the absence of these links which prevented kervit from becoming an alternative to the traditional majolica production system.

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* Cf. for example Freeman and Soete (1997, p. 216).
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