Long-term sustainability of clusters: A dynamic theory of declusterisation

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Long-term Sustainability of Clusters: A Dynamic Theory of Declusterisation.

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Complete List of Authors:	Marafioti, Elisabetta; Universita degli Studi di Milano-Bicocca, Department of Management (DISEADE) Mollona, Edoardo; Universita degli Studi di Bologna, Computer Science and Engineering Perretti, Fabrizio; Universita Bocconi, Department of Management and Technology
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Abstract:	In this paper, we build a System Dynamics simulation model to study the long-term counterintuitive consequences of internationalization strategies of machinery producers in industrial clusters. Our work proposes an explanation for declusterization, which is the decline and death of industrial clusters. While previous research puts in connection declusterization with increased competition, we mobilize Resource-Based View of the Firm, network approach to rent-generation and ecological modelling to provide a different perspective. Our study is original in its offering an endogenous explanation of declusterization. Namely, we explain declusterization as the long-term symptom of an unfolding process that starts with clusters' internationalization. Specifically, we suggest that the internationalization of machinery producers may lead to the interruption of the innovative process that grounds on the relational capital built in the original cluster and originated from the interplay of the various actors of the cluster. This phenomenon is particularly evident, we suggest, when considering the internationalization in the newly industrialized countries that started in the beginning of the 90's. To test this hypothesis, we articulated our research strategy in two steps. First, we collected empirical data on declusterization and clusters' exports towards newly industrialized countries. Second, we formalized our hypotheses on the causes of the observed phenomenon in a model, and we explored the behavior of the model through computer simulation. Comparing the adherence of model-simulated and real data we tested our hypotheses on endogenous causes of declusterization. Our work contributes to widening our perspective on the study of industrial clusters' dynamics at least under two perspectives. First, while, generally, research identifies in focal firms, or in other institutions that promote the development of a cluster, the engine of clusters' prosperity, we propose an evolutionary perspective that highlights the need to

	understand the development of clusters' lifecycle. Second, while most of current research suggests that internationalization strategies affect positively firms' performance and, therefore, internationalization is considered as an important driver for companies' growth, we warn on long-term, possibly undesired, consequences of clusters' internationalization.

Long-term Sustainability of Clusters: A Dynamic Theory of *Declusterisation*.

1. Introduction

The purpose of this paper is to study the long-term counterintuitive consequences of internationalization strategies of machinery producers in industrial clusters. To test a set of hypotheses that explain the decline and death of industrial clusters, we built a system dynamic simulation model.

Specifically, we mobilize Resource-Based View of the Firm (Penrose, 1959; Barney, 1991; Prahalad & Hamel, 1990) and ecological modelling (Hannan & Freeman, 1977; Boyce & Diprima, 1997) to explain the counterintuitive consequences of the internationalization of key actors of a cluster. The literature on clusters and districts provides an explanation for cluster performance and, more broadly, a rationale for their success (MacKinnon, Cumbers & Chapman, 2002; Human & Provan, 1997; Sydow & Windeler, 1998; Paniccia, 1998; Manskell & Malnberg, 1999). Other contributions focus their attention on the origin of clusters and on their evolution (Human & Provan, 2000; Gulati, 1998; Morel & Ramamujam, 1999) also highlighting the determinants of their widespread diffusion in literature (Lazzeretti et al. 2014). Few studies have tried to understand addressed the sustainability of clusters' lifecycle adopting an evolutionary perspective (Nadvi, 1999) and most of them have adopted aare context specific approach (Boschma & Fornahl, 2011). Our analysis focusses investigates the determinants ofits attention on clusters' decline concentrating on and death trying to identify the main drivers of this decline and the actions that can be implemented to invert this trend. Addressing the endogenous mechanisms of clusters' decline-, Wwe focus on a specific research question: "Is declusterization impacted more by cluster members internationalization or by foreign competition?".

Our analysis suggests that the interplay of competitive and commercial processes that connect actors within and between clusters are candidate endogenous explanations for the decline of clusters, a phenomenon that we have named *declusterization*.[1] In the face of many studies that argue how competition from outside has put into crisis this business model, we show how internationalization strategies, which are developed by the main actors of the clusters, may as well provide a persuasive endogenous explanation of declusterization.

~~The paper takes inspiration form insights that originate from three streams of literature: the research on clusters (and networks, if we adopt a broader perspective), the theoretical framework offered by the Resource-Based View of the firm (RBV) and the literature on relational capital. By adopting a combination of traditional econometric and non-conventional methodology based on simulation, we build a theory that we test by collecting empirical data in Italian footwear clusters.~~

~~This study also contributes to the broader literature on international business, with specific reference to internationalization processes. The mainstream literature tends to describe the internationalization process as linear and incremental, and identifies various phases of internationalization (Cavusgil, 1982; Johanson & Vahlne, 1977 and 1990; Root, 1998; Wiedersheim-Paul *et al*., 1978; Chang & Rozensweig, 2001; Menzel & Fornahl, 2009; Martin & Sunley, 2011). Most of these studies tend to suggest that internationalization strategies affect positively firms' performance and, therefore, that internationalization is an important driver for companies' growth. Focusing on the long-term consequences of internationalization strategies, we argue that internationalization may have harmful, counterintuitive, consequences for clusters' sustainability. Therefore, we contribute to this stream of literature by proposing a theory on~~

[1] Declusterization is also defined in economic literature as cluster decline (Menzel & Fornahl, 2009).

~~internationalization processes that focuses its attention on an aggregate of companies (the cluster) rather that the individual firm, as in the mainstream literature.~~

~~We also contribute to the advancement of the research on innovation analyzed from the point of view of aggregates of companies (collective innovation). Increasingly, a relational view of strategic management (Dyer & Singh, 1998; Lado *et al*., 1997; Madhok & Tallman, 1998; Paulraj *et al*., 2008) argues that the roots of companies' competitive advantage lies in their relationship rather than in the unique resources and competencies they possess individually. The interplay among actors is the main engine to generate and renovate the resources contributing to companies' competitive advantage. By adopting this perspective, it is also possible to provide a dynamic interpretation of RBV.~~

~~In general, T~~the heterogeneity of clusters' structure still poses significant barriers to systematic investigations (Staber, 1998). Most available studies on clusters are either static representations of an existing structure, or retrospective field studies that propose conjectures on the trajectory that a specific network undertook to reach the observed status. Differently~~eparting from this approach~~, to test our hypotheses, we adopt computer simulation as an experimental environment where we~~researchers are able to~~ scrutinize closely the link between a structure of interconnected statements regarding specific causal relations, crystallized in a set of assumptions, and the behavior that those assumptions postulate.

The paper is structured as follows. In a first theoretical section, we give a definition of industrial cluster; we combine the RBV of the firm and the network perspective to understand the innovation process that takes place within the cluster; we present the concept of relational capital; and we report current research on clusters' internationalization. The third section presents methodology, the fourth section develops our theoretical model and the fifth section presents the formalization of the model. In the following section, we report results. In the final session, we discuss results and their implications for theory and practice, limitations and future research.

2. Theoretical Background

2.1 Definition of Industrial Cluster

Industrial clusters (or districts) are geographically localized and complex networks of firms bound together in a social division of labor (Scott, 1986) that . Unlike the internal division of labor, which occurs when the connected activities required to produce a specific good or service are entirely controlled within the firm, a social division of labor occurs when the connected activities occur , and are distributed, among a population of small and medium-sized firms that perform highly specialized functions (Hayter, 1997). Therefore, industrial clusters' main features are a geographic concentration of activities, a population of small and medium-sized firms – often including Government and other Institutions - that are linked together by strong and frequent relationships and informal communication channels (Porter, 1989). Other scholars focus on the concept of industrial districts (Marshall, 1920; Porter & Ketels, 2009; Becattini & Rullani, 1993) further pointing out the relevance of social interaction among people and the social capital that the interaction creates. More specifically, according to Porter & Ketels (2009) clusters are "a natural manifestation of the role of specialized knowledge, skills, infrastructure, and supporting industries in enhancing productivity."

The firms of a cluster may be linked in three ways:~~. (Bellandi, 1982).~~ ~~First, firms can be linked~~ vertically, laterally and ~~when different stages of a process are involved. Second, firms may be linked laterally, when firms pursue processes that are placed at the same stage of the production process. Lastly, firms can be linked~~ diagonally (Bellandi, 1982).~~,~~ ~~when the delivery of services or products that support different stages of the production process is involved.~~ Referring to our research setting, the clothing industry, vertical linkages ~~materialize~~ occur in the case of spinning, weaving an, in general, when different sub-processes feed assembly lines. Horizontal linkages, for example, are those between men's clothing and women's clothing. Activities such as repairing, trading, collecting, etc. are diagonally linked production processes.

In industrial clusters, these links embed both inter-firm and interpersonal relationships and are deeply rooted in the local context and, therefore, take shape in specific historical and cultural backgrounds (Becattini, 1979). In the context of our paper, we focus our attention on the vertical relationship.

2.2 The RBV and Network Perspective to the Industrial Cluster

Resource-Based View ~~approach views the firm as a~~looks at endowments of ~~bundle of~~ resources and capabilities as~~and examines~~ the conditions that contribute to the realization of sustainable economic rents~~, to the study of industrial clusters~~. From this perspective, clusters are~~can be seen as a~~ unique combinations of tangible and intangible resources and capabilities that accumulate slowly and that are developed over time (i.e. they are history dependent variables) through complex interactions among co-localized firms (Gordon & McCann, 2000; Dahl & Pedersen, 2004; Iammarino & McCann, 2006). ~~Along these lines,~~ T~~t~~he resources of a cluster are tantamount the sum of the resources, defined as stocks of externally available and transferable factors (Amit, Schoemaker 1996), that are owned or controlled by the firms ~~belonging to~~of the cluster. In this light, particularly valuable are the knowledge-based inter-firms processes that govern (Dyer & Nobeoka, 2000) the exchange of resources between the different firms of the cluster and that make it possible the conversion of resources into final products and services.

Industrial clusters may provide substitutes for both vertical integration and diversification. To be effective, t~~T~~he~~is~~ substitution ~~to be effective, however,~~ requires ~~coordination~~ mechanisms to coordinate the exchange of knowledge[2] among the firms of a cluster. Spatial agglomeration provides the ground for such coordination mechanisms to emerge. Geographic proximity facilitates the building-up of reciprocal trust (Sako, 1992; Lazzeretti & Capone, 2016) and fosters co-specialized learning and cooperation (Dyer & Singh, 1996).

In previous studies applying RBV ~~approach~~ to industrial clusters, companies' competitiveness was the result of a combination of firm-based and cluster-based resources (Wilk & Fensterseifer, 2003). Less attention has been ~~assigned~~ dedicated to ~~the~~ cases in which ~~necessary~~ bundle of unique resources and ~~capabilities to the manufacturing and the development of competitive final products~~ are internal to a cluster but external to any single firm. We suggest that this case is more adequate to represent industrial clusters of small and medium non-differentiated firms. ~~This implies that the quality of the exchange that takes place among companies is fundamental in determining the competitiveness of companies. The connection between the stability of such exchanges and the health of the district in which the exchanges take place is an enthralling research question that, however, did not attract the attention of researchers.~~

[2] Knowledge can be divided in two categories (Kogut & Zander, 1992): information and know-how. Information is the knowledge that can be transmitted without loss of integrity once the syntactical rules for deciphering it are known. Know-how is the accumulated practical skill. Knowledge as information implies knowing *what* something means. Know-how implies knowing *how* to do something.

2.3 Relational Capital in Clusters

In ~~the context of the~~a social network approach to clusters' analysis, the concept of Coleman-type rents emphasizes how the sources of a cluster's competitive advantages are distributed among the cluster's firms and crystallize in the set of practices that these latter employ to coordinate the use of their resources and capabilities (Kogut, 2000). According to this point of view, valuable knowledge resides in industrial clusters rather than in specific firms.

This social network perspective (Granovetter, 1985; Maskell, 2001; Barney, 1991; Graebner, 2009) mobilizes the concept of *social capital* ~~to~~ for investigating~~e~~ the source of knowledge creation and transfer (Kostova & Roth, 2003; Nahapiet & Ghoshal, 1998; Bolino et al., 2002). ~~This is because~~ A~~a~~t the core of this analysis is the idea that valuable knowledge (i.e. that can contribute to the creation of a competitive advantage), is highly tacit, difficult to replicate and not easily purchased but~~, therefore it~~ can be created only through social interactions. Other studies ~~have pointed~~described ~~out~~ how social capital can ~~also~~ be recreated when geographic distance is high (Pucci et al 2017; Guerrieri et al., 2001). Most of these studies apply to~~are run within the context of~~ high-tech industries where explicit and codified knowledge is more relevant than in low-tech industry where knowledge is almost exclusively tacit. Interestingly, some recent studies have analyzed the evolution of innovation networks and clusters' lifecycle thereby preparing the ground for a better understanding of how relationships can evolve over time while maintaining the clusters' innovation capability (Desmarchelier & Zhang, 2018). Yet, a recurrent claim is that the impact of geography ~~in~~ on the resilience of innovation networks needs further attention.

Specifically, scholars have identified three mechanisms for the spatial transfer of knowledge within the boundaries of an industrial cluster: interfirm mobility of labor force, interaction between both users and makers of capital equipment and suppliers and customers, and spin-offs from ~~existing~~

~~firms or other institutions~~organizations belonging to the cluster (Keeble & Wilkinson, 1999). In this perspective, the concept of *relational capital* emerged as a subcategory of social capital (Kale, Singh & Perlmutter, 2000), with specific reference to the second of the above-described mechanisms. This provides a rationale for focusing on the vertical interactions that ~~happen~~ occur within a cluster. Furthermore, adopting a conventional classification of knowledge, most of our reasoning can be applied to labor-intensive clusters where knowledge cannot be easily codified and is incorporated in the machineries produced by downstream companies. ~~This specification is relevant because~~Thus, the limited codifiability of knowledge makes geographic proximity relevant in the development of relational capital. As observed by Uzzi (1997), building relational capital requires creation of trust, sharing of information and joint problem solving ~~and these are resulting in relational capital resources~~. While structural connections can be easily replicated and often provide a potential for knowledge transfer, relational capital is critical for successfully taking advantage of tacit knowledge (Collins & Hitt, 2006). ~~Within this context, interaction is key as well as possessing better relational capabilities that allow the realization of the benefits of these relationships.~~ Cultural differences play a role in negatively moderating this transfer (Collins & Hitt, 2006) and~~; therefore this~~ explain~~s~~ why knowledge transfer cannot be easily replicated in culturally different ~~and distant~~ contexts.

For example, in footwear clusters, there is often a tight relation between footwear firms and footwear machinery firms. ~~In order t~~To produce or to develop a product, the former must share portions of ~~their~~ knowledge with the latter in order to facilitate the design and fabrication of machinery that fits their needs. F~~The f~~ootwear machinery firms have to know the kind of materials their machines will~~have to~~ work with and~~,~~ the kind of different shapes and manufacturing needs. This implies the transfer of skills and expertise from machinery user firms to machinery producer firms in a circle of knowledge creation that takes place within the boundaries of a cluster that does not belong to individual companies (Capello, 1999).

2.4 Clusters internationalization

Internationalization of companies is a widely explored topic and various scholars have focused their attention on the internationalization process of SMEs and ~~namely on~~ industrial clusters (Bacchicchioni *et al*., 2014). Focusing on Italian clusters, ~~for example,~~ the most diffused form of internationalization is exporting~~, even if, there are few examples of foreign direct investments (FDIs), particularly among large firms~~ and~~. In this thread of research,~~ what emerges clearly is the positive impact of internationalization on growth and competitiveness. In times of economic crisis, internationalization provides both upward and downward a way to limit loss of competitiveness by expanding in new territories and relocating within of global value chains (De Marchi *et al*., 2014). However, none of these studies ~~on the topic~~ investigated the long-term impact of internationalization on clusters competitiveness. Some scholars analyzed~~have shed light on~~ how district internationalization in distant emerging markets ~~can lead to~~entails the~~a~~ redesign of the relationship between district home base and foreign district ~~in order to maintain district competitiveness and cluster-to-cluster relationships~~ (Bellandi & Caloffi, 2008). Other studies ~~A body of literature has explored~~investigated how production delocalization implies ~~in neighboring international locations and the role of the connected~~ knowledge transfer that ~~in~~ stimulates~~ing~~ the creation of new districts abroad. Yet, ~~T~~these analyses highlight the difficulties in relocating abroad the same set of relationships and the ability to generate innovation~~, mainly because of the lack and quality of final market demand~~ (Crestanello & Tattara, 2011). ~~Other~~ Another direction of research ~~studies~~ focus on the importance of clusters-generated spillovers on the capability of SMEs to innovate and ~~therefore~~ to maintain competitiveness in international markets (Libaersa & Meyer, 2011). In this thread of research, Boschma (2005), for example, investigated the role of geographic proximity (along with other types of proximity such as cognitive, organizational, social and institutional) on innovation and explained how proximity has a twofold effect. A positive effect ensues from the close exchange of information; a negative effect, however, occurs because of the excessive idiosyncrasy of knowledge accumulated and connected lock-in effects.

None of the previous studies, however, explores how the international strategies adopted by the actors that holding different positions (upward and backward) in a cluster affect clusters' lifecycle and competitiveness.

3. Methodology

We adopt an original research strategy in which we blend computer modelling and simulation, and empirical analysis. In a first step, we collect data on Italian clusters of firms producing footwear to analyze demographic trends in manufacturing clusters. In a second step, we use formalization and computer simulation to test a number of hypotheses that explain the empirical observed behavior observed in the collected empirical information. Specifically, in a previous study (XXX[3], 2008) we empirically showed how footwear machineries exports (Fig. 1) during the period 1970-2005 may have negatively affected the density of footwear producers (Fig. 2). In this paper, we use a formal model to understand and to simulate the mechanisms behind such relations.

Grounding on the analysis of received literature and of secondary data, we built Tourhe formal model[4] was built grounding on the analysis of received literature and of secondary data (Malerba, Nelson, Orsenigo & Winter, 1999). We formalized a set of interrelated assumptions that describe

[3] Names erased to maintain anonymity of authors.
[4] The model is available for inspection from authors upon request.

the exchanges of goods and knowledge among populations of firms located both in the same and in different districts. The longitudinal and complex nature of these exchanges makes it is difficult to explicate how their relationships unfold over time to yield different aggregate results. Yet, we observed ~~T~~the unfolding of these processes ~~can be observed, however, i~~in a set of computer simulations (Davis, Eisenhardt & Bingham, 2007). ~~Using computer simulation, we deduced plausible unfolding competitive and commercial dynamics among firms in clusters.~~

A caveat concerns ~~that~~ the use of a simulation approach to test hypotheses about interesting phenomena (Kollman, Miller & Page, 1997: 462). When we use the word “test” we are not suggesting that we are operating a statistical test. Rather, we are testing a candidate explanation of an observed phenomenon producing an abductive inference. Abduction is an inference that goes from the observation of a fact to the hypothesis of a principle that explains the observed fact (Burks, 1964; Fann, 1970). As Peirce himself explains (1901/1955), the form of this inference proceeds as follows “The surprising fact, C, is observed; But if A were true, C would be a matter of course, Hence, there is reason to suspect that A is true” (Peirce , 1955: 151).In our study, declusterization is the surprising observed fact. The formal model crystallizes hypotheses that explain the observed fact.

Therefore, our model belongs to a class of computer models that are “history friendly” because of their adherence to the empirical realm object of investigation (Malerba, Nelson, Orsenigo & Winter, 1999). In this respect, Hanneman, Collins & Mordt suggest that ‘Computer simulation methods help to bridge the gap between theory and history’ (1995: 4).

~~Taking this approach,~~ A~~a~~ fundamental step to build confidence in our model is to test its ability to explain the key traits of the phenomenon of declusterization. Hence, we selected a set of empirical data that clearly portray a case of declusterization. The more the data collected to build our model reflects the behavior under investigation, the more our theory development process is facilitated.

When empirically collected ~~reference modes~~data clearly show the behaviors that define a specific phenomenon, the modeler increases her capability to test her model by assessing whether this latter is able to reproduce the symptoms that makes the phenomenon under study interesting. T~~his need t~~o produce this ~~a~~ symptom-based test of behavior, we ~~motivated us to~~ collected data able to (*i*) reproduce the phenomenon of declusterization (*ii*) from its onset to the completion. This explains the selection of data located in the past that fully illustrate the unfolding of the phenomenon of declusterization from its outset until its full completion.

3.1 The Sample

We ~~choose our~~ sampled ~~of~~ clusters in the~~selecting~~ footwear machinery industry as one of the most competitive industries in Italy ~~; furthermore, these are industries~~ where companies are organized in geographical clusters with a vertically integrated structure. Collecting secondary data in the period 1970-2002, ~~W~~we ~~have~~ created a database of~~on~~ clusters' ~~the~~ populations (final producers and machinery producers) ~~of the cluster, collecting secondary data in the period 1970-2002~~. ~~Because of the l~~Lacking ~~of~~ a systematic data source, we~~the~~ created our database ~~has been created~~ combining and cross-checking data from various data sources ISTAT[5], EUROSTAT, and further elaboration on ISTAT data provided by the main trade associations (Assomac and ANCI). We adopted~~Adopting~~ the classification of clusters proposed by ~~the~~ Decree n.206/93 and applied by Regional governments in Italy~~throughout the Italian territory~~[6] in combination with the classification proposed by the Club dei Distretti.[7] By combining these two data sources, ~~it has been possible to~~we identif~~y~~ied 13 footwear clusters.[8]

[5] Italian Bureau of Statistics

[6] According to the above mentioned law, Italian regions have been asked to map regional specialization areas (*distretti*).

[7] It is the association represented all the Italian districts.

[FIGURE 1 ABOUT HERE]

[FIGURE 2 ABOUT HERE]

3.2 Modelling and Simulation

Following Sastry (1997), Romme et al. (2010), and Rahmandad & Sterman, (2012), we developed the a simulation model adopting a system dynamics approach (Forrester, 1961; Morecroft, 1985; Sterman, 2000). We first developed a causal model of firms' internationalization and declusterization that we report in figures 3 and 4. In a second step, we transformed the qualitative causal model into a formal model. Specifically, Tthe model includes several equations that govern the behavior of a number of state variables. State variables capture the key concepts that make out the theoretical framework previous presented. Standard continuous-time notation represents differential equations to describe the behavior of state variables. The value of the generic state variable *x*, at time *t*, is the integral of previous changes as follows: $x_t = \int_0^t \frac{dx}{dt} + x_0$. ThereforeThus, our formal model is described as a system of differential equations. The We simulated the formal model was then simulated using Vensim DSS© simulation software[9]. In the simulated model, the numerical solution of a system of difference equations approximates the behavior of a system of differential equations. The numerical solution of the system of difference equations is obtained by using Euler integration technique with a time step of 0.25.

[8] Montebelluna (BL), Riviera del Brenta (VR), Vigevano (PV), Parabiago (MI), S. Croce sull'Arno (PI), Valdinievole-Leporecchia (PT), Macerata-Fermo (MC), Fusignano-Bagnacavallo, S. Mauro Pascoli, Val Vibrata, Barletta, Castrano, Napoli

[9] Ventana Systems Inc. The version of the software is 5.9c.

4. A Causal Model of Internationalization and Declusterisation

Grounding on the reported review of the literature, we commence our speculation from three assumptions.

First, we refer to the concept of Coleman-type rents that associates clusters' competitive advantages to resources and capabilities that are distributed among clusters' actors (Kogut, 2000). ~~. Specifically, ~~W~~w~~e focus on the concept of relational capital as a subcategory of social capital (Kale, Singh & Perlmutter, 2000).

Thus, we assume:

ASSUMPTION 1: In an industrial cluster, the resources and capabilities that are vital for firms to succeed in domestic and international competition are relational.

We emphasize the value of tacit and difficult to replicate knowledge created through social interactions among firms within clusters. Therefore, we assume that the accumulation of relation capital develops from the interaction between users and makers of capital equipment and suppliers and customers (Keeble & Wilkinson, 1999).

ASSUMPTION 2: The primary locus in which relational capital develops is in the commercial relations among firms at different stages of the supply chain that incorporates knowledge exchange. Therefore:

ASSUMPTION 3: Relational capital develops at cluster level rather than within any single firm.

As suggested by Kogut (2000), in a network of firms, two kinds of rents may emerge. The first type of rent is defined by borrowing the concepts of 'structural hole' and 'non-redundant tie' put forward by Burt (1992). ~~When a node ~~By o~~o~~ccupying~~ies~~ a structural ~~node~~hole, a node~~it~~ acquires~~s a~~ powerful brokerage position since it~~it~~ becomes the only route to connect two~~the~~

previously isolated nodes. ~~and~~ This privileged position produces a ~~the so-called Burt~~ rent that ~~derives from a privileged position in a network and~~ accrues to the firm that plays the role of broker.

The ~~definition of the~~ second type of rent follows from Coleman's analysis of the role of multiple redundant ties among nodes in a network (1990). According to Coleman, redundant ties produce a dense web of relationships in which the reciprocal control that nodes have ~~reciprocal control~~ that ~~. This reciprocal control results in the solution of~~solves collective action problems and ~~in~~ improve~~d~~s interfim coordination ~~among firms~~.

While in the case of Burt-type rents, the unit of accumulation of rents is a single firm, ~~which owns a valuable resource to which clear property rights are associated,~~ in the case of Coleman-type rents the unit of accumulation is a ~~group~~ network of firms.

In the case of inter-organizational networks, in which firms enjoy coordination rents that are produced by shared knowledge, we are typically in presence of Coleman-type rents since 'intellectual property right resides at the network, rather than firm level' (Dyer & Nobeoka, 2000).

In figure 3, we describe how, within clusters, we assume that the commercial exchange between a supplier and a client (solid arrow) develops as well a reciprocal exchange of knowledge (dotted arrows), namely relational capital.

[FIGURE 3 ABOUT HERE]

We now assume that domestic machine producers decide to grow internationally. The internationalization of machinery producers activates the link labelled 2 in figure 4. ~~Machines~~ E~~e~~xports by machinery producers, which belong to an industrial cluster, ~~is~~ not only is the export of a product but ~~also~~ implies the transfer to other countries of capabilities that have been developed inside the cluster ~~itself~~. This is especially true in newly industrialized countries (NICs) where~~,~~ ~~because~~ the first stage of industrialization is characterized by growing imports of machinery

(Aulakh, Kotabe & Teegen, 2000). The transfer of capabilities is unavoidable in the case of machines export when because they incorporate knowledge so that machinery producers have to teach to the clients how to use the machines they have sold to them. The more specialized the machines are, the more machinery producers have to transfer the skills necessary to manufacture the product that their machines are able to produce. This is also due to the increasing international competition in the machinery industry.

[FIGURE 4 ABOUT HERE]

Grounding on seminal work in economic geography, we describe the emergence of an industrial cluster as an autocatalytic process in which settlements of suppliers and clients is reciprocally reinforced (Krugman 1992, 1996, 1997; Krugman, Venables & Fujita 1999). Thus, the growing demand for machinery, which is generated by the progressive growth of a number of finished goods producers, along with the need of maintenance services, create the incentives for a number suppliers of machines to co-localize in the newly emerging settled cluster (solid arrow labelled 3 in figure 4). Again, the exchange of services and machinery cannot take place without an intertwined flow of knowledge. In figure 4, this is described by the solid arrow labelled 3 along with the connected dotted arrow representing knowledge transfer from users to suppliers. The unidirectional knowledge transfer from clients, who had access to foreign technology, is gradually transformed, we suggest, into a bidirectional knowledge exchange that gives rise to the construction of relational capital in the new foreign cluster (this is described in figure 4 by the the dotted arrows representing knowledge transfer from users to suppliersfigure 4). The activation of commercial relation (2), we suggest,

We are particularly interested in the affectsconsequences that the activation of commercial relation (2) has on the competition among finished goods producers.

We focus on two consequences: 1) it is no longer possible to sell to final markets in NICs older versions of the product, thus maintaining a gap between domestic clients and foreign ones; 2) the transfer of machines and skills to the producers located in NICs assign to these latter an important instrument of differentiation (Buckley, Clegg & Chengqi, 2007).

Thus, the finished goods producers in the emergent foreign cluster come to compete on similar market segments, as described by commercial relations 4 and 5 in figure 4.

We are not saying that the domestic and the foreign finished goods producers come to share identical resource and capabilities. Machinery producers do not have, and hence cannot transfer, the resources and capabilities necessary to bring the product to the market. Thus, probably, domestic finished goods producers maintain superior capabilities in design and marketing.

We are saying that, because of the transfer, they have the same competence in the manufacturing of the product. Both are able to manufacture the same product. With a difference: in some cases, the foreign ones, when located in low labor cost countries, have a cost advantage. The emerging competitive pressure is described by the arrow labelled 6 in figure 4.

In addition, ~~we may suggest that~~ the weakening of the downstream firms has an undesired, long-term, feedback on machine producers. These latter may be challenged by foreign machine producers, who have developed competitive skills and technology (competitive link 7 in figure 4). The erosion of the population of downstream firms in the cluster weakens the critical mass of cluster-level resources, both human and technological (Temple, 1998).

~~In general, however~~Thus, independently of the likely impact on upstream machine producers, the distinctive feature of an industrial district, we suggest, fade away as soon as downstream finished goods producers weaken.

This is because clusters are networks of relations (Powell, 1990) whose “glue” is represented by the existence of trust and the ability to diffuse and to create knowledge (r~~R~~elational capabilities creating relational capital) to react fast to environmental changes. When one of the nodes of the web of relationships dies out, hardly can this latter be substituted with another node that is located outside the cluster. T and, Therefore, the competitiveness of the whole cluster weakensloses portions of its competitiveness.

Concluding, the key message conveyed by our model is that when there is no cooperation between the machinery industry firms ("upstream firms") and the cluster user firms ("downstream firms") the internationalization strategy of the former can lead to the declusterization (diminished competitive advantage, gradual impoverishment of resources and capabilities, exit of some firms) with negative effects upon the whole cluster.

Based on the analysis of the interrelated processes described in figure 4, to explain the described dynamics in the clusterdeclusterization, we suggest the following hypotheses:

H1: The internationalization of a cluster's members may threaten the cluster's relational capital thereby offering an endogenous explanation of declusterization.

H2: The internationalization of a cluster's members may erode the cluster's relational capital by exporting knowledge to foreign clusters, weakening the competitive advantage of domestic supply-chain and impoverishing the network of the cluster's commercial relationships.

H3: The speed of declusterization is positively correlated with the speed of erosion of relational capital, which is, in turn, is connected with the speed of internationalization.

H4: The speed of declusterization is positively correlated with the speed of erosion of relational capital, which is, in turn, is connected with the knowledge content of exports.

H5: The higher the limits to growth of domestic foreign goods producers, the earlier a process of declusterization begins.

5. Formal Model

To explore the dynamic behavior of the model portrayed in figures 3 and 4 we generated a formalization. We developed a stylized model in which two populations are originally co-localized in a focal geographical cluster, one supplies machinery and the other one produces finished goods. Two further populations, one of machine suppliers and one of finished goods producers, are co-localized in another geographical cluster.

We connected our formalization to the qualitative model in three steps. We first we modelled the vertical commercial relations, second we model the horizontal competitive relationships, finally we modelled the dynamics of knowledge sharing. To model interaction among these populations, we adopt an ecological perspective.

As for vertical commercial relations, finished goods producers create a resource niche for competing populations of machine suppliers. On the other hand, populations of finished goods producers, impinge on the same niche of resources, that is, the market of final users. Therefore, we modelled vertical commercial relations using the concept of ecological niche. A population is an ecological niche for, and grants survival to, the population positioned upstream.

Second, we modelled the horizontal competitive relations between two populations of firms as the competition between two different species that are located in the same ecological niche and we assumed that the competition is based on the price and on the technological content of products. We assumed that firms in the focal cluster have both higher technological level of productive processes, and operate with higher costs and selling prices. On the other hand, populations co-localized in a different geographical cluster have lower production costs and selling prices, and, initially, a low level of technology embodied in the productive process.

Finally, we assumed that building vertical inter-cluster commercial relations implies technological transfer that influences horizontal inter-clusters competitive relations. Consequently, we modelled the downstream population's competiveness as depending on the exclusivity of the commercial relations with the upstream population. In this way, we accounted for the tight within-district relationship as described by the Coleman assumption.

Our modelling explores the consequences in the focal geographical cluster of the internationalization of machine producers' population. More Sspecifically, we investigate the unfolding of the dynamics that are triggered when machine producers start to supply finished goods producers localized in a different geographical cluster.

Since we model competition among population of firms, we adopted the theoretical framework of the competing species model (Hannan & Freeman, 1977). We used this model as a starting point for modelling because it is compact and well documented in the literature. We direct interested readers to Boyce and Diprima (1997) for a complete analysis of the model. Of course, we modified the competition model coherently with our theoretical framework.

Following Hannan and Freeman modelling, we use the equation $\frac{dPop_i}{dt} = g_1 \cdot Pop_1 \cdot \left(\frac{r - c_{ji} \cdot Pop_j - Pop_i}{r}\right)$ to describe competition among populations of both suppliers and finished goods producers.

In the equation, *i* and *j* represent competing populations, g_i is the rate of growth of population *i*, *r* is the resource available in the niche in which the two populations *i* and *j* are competing. In our case, *r* can be interpreted as the number of firms that are clients of the populations within the same niche.

The parameter c_{ji} is the competitive aggressiveness of population *j* on population *i*. The competitive aggressiveness can be considered as the probability that a member of population *j* beats a member of population *i* in acquiring resources. In our model, the advantage in acquiring resources represents a competitive advantage in reaching a consumer who belong to the downstream market.

Thus, had *c* to be equal to one, population *j* will always be more competitive than population *i* in acquiring scarce resources.

Therefore, if we call $Pop_{m_1}$and Pop_{m_2} two populations of machine suppliers that compete in the same niche, Pop_{g_1} and Pop_{g_2} two populations of finished goods producers that compete in the same niche, and *u* the number of firms that represent final users of the finished goods produced by $Pop_{g_1}$and Pop_{g_2}, the rate of growth of the four populations is modelled as:

$$\frac{dPop_{m_1}}{dt} = g_{m_1} \cdot Pop_{m_1} \cdot \left(\frac{\left(Pop_{g_1} + Pop_{g_2}\right) - c_{m_2 m_1} \cdot Pop_{m_2} - Pop_{m_1}}{\left(Pop_{g_1} + Pop_{g_2}\right)} \right) \quad (1)$$

$$\frac{dPop_{m_2}}{dt} = g_{m_2} \cdot Pop_{m_2} \cdot \left(\frac{\left(Pop_{g_1} + Pop_{g_2}\right) - c_{m_1 m_2} \cdot Pop_{m_1} - Pop_{m_2}}{\left(Pop_{g_1} + Pop_{g_2}\right)} \right) \quad (2)$$

$$\frac{dPop_{g_1}}{dt} = g_{g_1} \cdot Pop_{g_1} \cdot \left(\frac{u - c_{g_2 g_1} \cdot Pop_{g_2} - Pop_{g_1}}{u} \right) \quad (3)$$

$$\frac{dPop_{g_2}}{dt} = g_{g_2} \cdot Pop_{g_2} \cdot \left(\frac{u - c_{g_1 g_2} \cdot Pop_{g_1} - Pop_{g_2}}{u} \right) \quad (4)$$

To model the competitive aggressiveness, we use a weighted average of the impact on competitiveness of both price and the level of technology embodied in the production processes of the different populations.

The idea is that firms compete on two dimensions. First, they compete in term of pricing. Second, they compete on the level of technological advancement of production processes at work in their supply-chain. Technological advancement derive from commercial relationships that facilitate knowledge sharing between actors at different stages of the supply-chain.

In our model, in a niche, dynamics of competition and the different aggressiveness of a competing population depend on three elements. First element is the relative pricing of products. A second is the relative technological content of products. Third element is the balance between price elasticity and responsiveness to technological advancement of products that characterizes the niche. The more customers in a niche regard as important technological content of products, the less importance will be given to price differences. In other words, ~~firms~~ clients may be ready to pay a bit more for more technologically advanced supplies.

Thus, referring to two generic populations *i* and *j*, we modelled $c_{ij} = k_{ij} \cdot \phi + p_{ij} \cdot (1 - \phi)$ where k_{ij} and p_{ij} are the differential advantage of population *j* on population *i* in terms of, respectively, technology and price and ϕ is the weight assigned to technology with $0 < \phi < 1$.

Grounding on information collected in our field study in the shoe-making industry, ~~in our modelling,~~ we defined the competition among finished goods producers as based only on price. On the other hand, we modelled competition between machine producers as combining both price and technology advancement of the machines.

Thus, in the finished goods production, we set $\phi = 0$ and $c_{g_1g_2} = p_{g_1g_2} = \frac{p_{g_2}}{p_{g_1} + p_{g_2}}$ and $c_{g_2g_1} = p_{g_2g_1} = \frac{p_{g_1}}{p_{g_1} + p_{g_2}}$ that is, competition is based upon price alone. The formulation implies that the competitive aggressiveness of population *j* increases as the average selling price of population *i* exceeds average selling price of populations *i* and *j*. Had average selling price of population *j* to be equal to zero, its competitive advantage will tend to be equal to 1, meaning that any member of population *j* has a competitive advantage on any member of the competing population.

In the machine production sector, we modelled $c_{m_1m_2} = k_{m_1m_2} \cdot \phi + p_{m_1m_2} \cdot (1 - \phi)$ and $c_{m_2m_1} = k_{m_2m_1} \cdot \phi + p_{m_2m_1} \cdot (1 - \phi)$. The price component of competition is modelled as in the case of finished goods producers; hence, $c_{m_1 m_2} = p_{m_1 m_2} = \frac{p_{m_2}}{p_{m_1} + p_{m_2}}$ and $c_{m_2 m_1} = p_{m_2 m_1} = \frac{p_{m_1}}{p_{m_1} + p_{m_2}}$. We introduce k_{ij} t~~T~~o model the technological component of competition ~~we introduce k_{ij}~~. We assume that k_{ij} ranges from zero, when technological level is equal in the two population of firms, to one, when difference in technological level of productive processes is the largest achievable.

We assume that the population of machine producers in the domestic cluster has reached maximum achievable technology level while in another competing cluster, in a different geographical area, the technology level is still at its minimum level. -Therefore, the population of machine producers that is a technology follower will be able, at best, to minimize the impact of technology gap with the technology leader and we set- $k_{m_2 m_1} = 0$. To explain the logic underpinning the modelling of $k_{m_1 m_2}$, we focus on processes of knowledge sharing. We assume that a knowledge sharing process follows from internationalization processes and takes place when machine producers start to supply machines to finished goods producers localized outside the focal geographical cluster. This knowledge sharing process is activated by machines' export and benefits machines' users that are localized outside the focal cluster through the transmission of the information and know-how necessary to both install production capacity and to implement production processes.

To make exports endogenous to our model, we assume that when the population of machine suppliers in a cluster grows, they need to find new markets and start to feel a pressure to export.

Pressure to export is a central concept to capture unfolding competition among populations of firms localized in different geographical cluster. Notwithstanding its theoretical importance, pressure to export hardly can be empirically observed and, therefore, it is often ignored in theorizing. To transform such a concept into a construct, we built a standardized measure of demographic pressure to export by considering the ratio $\frac{Pop_{m_1}}{Pop_{g_1}}$. Consequently, the dynamics of technological gap among finished goods producers is calculated as $k_{m_1 m_2} = \frac{1}{\frac{Pop_{m_1}}{Pop_{g_1}}}$.

6. Experimental setting

To run our simulation experiments, we calibrated the model reproducing the key traits of the industrial districts that we analyzed. Table 1 reports our calibrations. Namely, we used the data collected in the 13 footwear clusters mentioned in section 3. As reported in figure 2, we consider a domestic cluster with 100 finished good producers and 4 machine producers. Based on our interviews, we defined a density dependent rate of growth – the rate at which a population of firms influences the creation of new firms by a process of imitation – grounding on the hypothesis that barriers to mobility are higher for machine producers than in the finished goods segment in which very easily individual firms may enter the industry. In addition, we assumed that in the nascent foreign cluster the rate of growth is higher than in the domestic cluster. In table 1, we report the rates of growth that we used in our simulations.

To calibrate $p_{m_2 m_1}$, $p_{m_1 m_2}$, $p_{g_1 g_2}$ and $p_{g_2 g_1}$ we analysed prices both in the domestic clusters that are object of our study in Italy and in a number of foreign clusters that maintain commercial relations with the Italian clusters.

Then, we calibrated prices in order to reproduce the cost advantage that foreign clusters maintained in the period of observation. In addition, we assumed that exports flow towards a foreign emerging geographical cluster in which one machine producer and 50 finished goods producers are located. Based on data from field experts, we set the number of the final users of finished goods that are clients of the domestic cluster (u), mainly large apparel producers, equal to 500.

Since the field studies, which we used to calibrate the model did not always provide suitable numerical data but did provide detailed qualitative insight that can be represented formally, similar to Sastry (1997), we developed formulations to yield operating points in the zero-unit interval when possible. This scaling was chosen for convenience. For example, we set ϕ, the weight of knowledge differential compared to price differential in the formation of competitive advantage, equal to 0.3 to describe a setting in which price is more important that the knowledge content of the products in the competitive rivalry.

We run simulation in a time horizon that runs from 1970 to 2005~~, with a time step in each month~~. This time horizon was chosen for convenience since we observed the phenomenon, and collected empirical data, in the same time interval.

To assess and discuss the match between real and simulated data we use the method of Theil's inequality, which is a decomposition of the mean squared error between two time series, as reported by Sterman (1984). The idea behind this approach is to interpret the forecast error, that is, the difference between simulated and actual time-series, by decomposing the mean-square-error (MSE) calculated as $MSE = \frac{1}{n}\sum_{t=1}^{n}(S_t - A_t)^2$ In the calculation of MSE, S and A are, respectively, simulated and actual time series, and n is the number of observations, that are simulation steps. Thus, the Theil statistics derive from the following decomposition:

$$\frac{1}{n}\sum_{t=1}^{n}(S_t - A_t)^2 = (\bar{S} - \bar{A}) + (S_S - S_A)^2 + 2(1 - r)S_S S_A$$

where

$$\bar{S} = \frac{1}{n}\sum_{t=1}^{n}S_t;$$

$$\bar{A} = \frac{1}{n}\sum_{t=1}^{n}A_t$$

$$S_S = \sqrt{\frac{1}{n}\sum_{t=1}^{n}(S_t - \bar{S})^2}$$

$$S_A = \sqrt{\frac{1}{n}\sum_{t=1}^{n}(A_t - \bar{A})^2}$$

$$r = \frac{\frac{1}{n}\sum_{t=1}^{n}(S_t - \overline{S})(A_t - \overline{A})}{S_S S_A}$$

By dividing each component of the Theil's inequality by the MSE, we obtain three statistics:

$$U^M = \frac{(\overline{S} - \overline{A})^2}{\frac{1}{n}\sum_{t=1}^{n}(S_t - A_t)^2}$$

$$U^S = \frac{(S_S - S_A)^2}{\frac{1}{n}\sum_{t=1}^{n}(S_t - A_t)^2}$$

$$U^C = \frac{2(1-r)S_S S_A}{\frac{1}{n}\sum_{t=1}^{n}(S_t - A_t)^2}$$

The three statistics measure different components of error. The difference between means measures the bias between simulated and actual time series. The difference between standard deviations captures the 'unequal variation' (Sterman, 1984: 54) between simulated and actual time series. The last term reports the 'the degree to which the changes in the simulated series fail to match the changes in the actual series on a point-by-point basis' (Sterman, 1984: 54). It is important to remind that we are not concerned with the precise replication of empirical data. Rather, we use simulation experiments as 'observation-generating mechanisms' (Lomi, Larsen & Wezel, 2010: 137) and we use pattern-matching to assess whether our model is able to reproduce the 'symptom' (Forrester & Senge, 1980) of the empirical phenomenon under study.

7. Simulation Results

[TABLE 1 ABOUT HERE]

We report ~~Main results of~~ simulations ~~are reported~~ in figures 5, 6 and 7. In figure 5, we simulated the behavior of four populations of firm located in two industrial districts in competition. ~~As shown,~~ W~~w~~e simulated a lifecycle of a "domestic" cluster (the cluster that includes the incumbent populations), from growth to declusterization. The simulation suggests that the causal model represented in figures 3 and 4, once simulated, is able to produce behaviors similar to those observed in figure 2, especially as far the declusterization of incumbent finished good producers is concerned. In the graph of figure 5, between 1980 and 1985, domestic finished good producers (line 3) start to decrease and are outdone by the population of finished goods producers in the foreign cluster in which domestic machine producers directed their exports (line 4). In parallel, in figure 2, we observe that real data shows that, in the same time interval, the rate of exit from the domestic finished good producers start to supersede the rate of entrance thereby producing a negative net rate of change in the overall population.

[FIGURE 5 ABOUT HERE]

[FIGURE 6 ABOUT HERE]

In figure 6, we show the matching between simulated and actual density time series. In addition, Wwe applied Theil's inequality to analyze the composition of the error between the two series.

The three components of the inequality are as follows:

$U^M = 0.03$

$U^S = 0.73$

$U^C = 0.24$

As expected, $U^M + U^S + U^C = 1$.

Our aim was to capture a specific longitudinal pattern of behavior, with the surge of a population of finished goods producers that reaches a peak and starts to erode within a specific length of time after the beginning of internationalization by machine producers. Most of the error in reproducing the real data refers to the second term U^S. This suggests that the actual and the simulated series have the same phasing and different magnitude fluctuations. Therefore, pattern matching suggests that our simulation is able to capture the behavior of interest that is depicted by the phasing of the oscillating behavior of finished goods producers. The residual error depends on the failure of the model to produce a point-by-point prediction (term U^C) (Sterman, 1984).

Particularly important is the role of the construct that we labelled *pressure to export* and that we modelled as the ratio between machine producers and finished goods producers. This ratio mimics the saturation of domestic machinery market and represent an endogenously generated pressure to export.

In figure 7, we observe the expansion of the domestic cluster, with an initially growing number of finished goods producers. The population of finished goods producers provides a niche for local machine producers that, hence, do not need to export (see decreasing curve 1)., and, therefore, The decreasing needs to export contributes to maintaining knowledge within the cluster (see increasing curve 2). Between 1970 and 1982, however, the population of domestic finished good producers grows at a decreasing rate because of the saturation of the market for finished goods. In 1982, however, in figure 5, domestic machine producers are still growing but their domestic market for machinery saturates. Therefore, domestic machine producers start their process of internationalization. As shown in the graph, in the simulation, pressure to export decreases to reach its minimum in 1982 (dotted line in the graph) and starts to rise because domestic machine producers grow while domestic finished good producers reached their limit to growth.

Internationalization, however, triggershowever, brings about knowledge transfer and the erosion of the cluster's relational capital along with the capability advantage of domestic cluster that dissipates to leave place to the emerging foreign cluster. The idea here is that a self-reinforcing mechanism is triggered. That is, as simulations in figures 5 and 7 report, the population of domestic finished goods producers erodes at an increasing rate. The more the number of domestic finished good producers decreases, the more pressure to export boosts thereby producing further decreases in the population of local finished good producers.

In figure 8, we depict ~~T~~the feedback structure that explains the reported dynamics~~ is illustrated in figure 8~~.

In the graph, plus (minus) sign between two variables signifies that the two variables move in the same (opposite) direction. Namely, with a plus (minus) sign, if the variable at the beginning of an arrow moves up, the variable at the end of the arrow goes up (down)[10].

The feedback loop that we marked with "1⁻" explains ~~T~~the decrease in the growth rate of domestic finished goods producers, between 1970 and 1982~~, is explained by the feedback loop that we marked with "1⁻"~~. Balancing loops are homeostatic mechanisms that ~~tend to~~ counterbalance exogenous disturbances.

When the population of firms grows, the market share saturates thereby exerting a pressure that counterbalances, and slows down, the ongoing growth. This mechanism explains the deceleration ~~of~~ in the growth of the population of ~~the~~ domestic finished goods producers.

On the other hand, the reinforcing feedback loop that we marked with a "1^{+}" explicates the exponential decay, between 1982 and 1990, in the same population~~, is explained by the reinforcing feedback loop that we marked with a "1^{+}"~~.

Reinforcing loops have the characteristics that, if any of the interconnected variables receives a jolt, the signal is amplified as it is transmitted along the loop to reinforce the initial disturbance and to foster an exponential growth or decay.

[10] In the diagram, the '+' ('-') sign implies a positive (negative) correlation between two variables as follows: $x \underset{+}{\rightarrow} y \; yields \; \frac{\partial y}{\partial x} > 0$ and $x \underset{-}{\rightarrow} y \; yields \; \frac{\partial y}{\partial x} < 0$.

When the population of machine producers starts to grow and to export, skills and knowledge are transferred abroad, relational capital deteriorates and the competitive pressure from foreign finished good producers becomes stronger. Consequently, the population of foreign finished good producers expands and reduces that market share available for the population of local finished good producers that start eroding. The contraction of this latter population, however, increases the incentive of local machine producers to export thereby reinforcing the transfer of knowledge and skills abroad. Interestingly, we suggest, the pressure to declusterization emerges endogenously as the consequence of the mismatch in the trajectories of growth of the population of firms at different stage of the supply-chain within the same cluster.

If machine producers want to keep their growth, they ~~are forced~~need to find clients outside their cluster. In doing so, however, they trigger a mechanism of substitution of domestic finished goods producers with foreign finished goods producers.

Yet, in both figures 5 and 7, looking at the pattern of the population of local finished good producers, we notice that, beginning from 1995, the decay occurs at a decreasing rate. In other words, the domestic population of finished goods producers tends to stabilize. This is explained again by the balancing loop in the left hand side of the diagram, which we marked with "1-".

Balancing loops tend to counterbalance, and absorb, external disturbances. This exactly what is happening in the population of finished goods producers. When competition reduces available market share, thereby triggering the erosion of the population, the number of firms in this population shrinks and the market share available increases for the firms that survived selection. Put differently, feedback loop 1- describes the adjustment process through which the local population adjusts after foreign competitors have withdrawn a portion of its market.

Finally, in the long term, we expect that a second balancing loop may intervene to ~~cut~~ stop the internationalization of clusters. With the increase in the competitiveness of foreign finished good producers, we expect that a local population of machine producers may emerge that will reduce import of machinery. In this perspective, the loop marked "2-", in the top right side of the diagram, represents another mechanism that, over a longer horizon, may curb the internationalization process.

[FIGURE 7 ABOUT HERE]

[FIGURE 8 ABOUT HERE]

8. Discussion and Conclusion

Our simulation experiments suggest that the theoretical framework, which we traduced in a system dynamics model, provides a plausible candidate explanation of declusterization. Specifically, once simulated, the model produces a behavior that captures the key traits of the phenomenon of declusterization. At the core of our explanation is the concept of relational capital. The analysis of the relation between the simulated behavior and the feedback structure of the formal model, however, unveils the complex tissue of cause-effect relationships in which the concept of relational capital is embedded. This analysis casts some light on how relational capital mediates the interaction between clusters' internationalization and declusterization.

In figure 5, the decreasing curve 3 between 1982 and 1995 portrays the phenomenon of declusterization. The exponential decay crystallized in the curve is produced by feedback 1^+, which depicts the interaction among clusters' internationalization, erosion of relational capital, and declusterization as suggested by our hypotheses 1 and 2. The speed at which declusterization occurs can be observed, again in figure 5, as the slope of curve 3 between 1982 and 1995.

The slope, in turn, depends on the working of feedback 1^+; the stronger the feedback, the faster the erosion of the population will be. This confirms our hypothesis 3, which connects the speed of declusterization to speed of internationalization. In our model, the stronger will be the effect of cluster's saturation to the export of machinery to foreign clusters, the stronger will be the feedback response in terms of pressure towards the erosion of domestic population of finished goods producers. On the other hand, the larger technological content of production is, the stronger the transfer of knowledge connected to machinery export will be, thereby assigning to feedback 1^+ a stronger acceleration. This will result in faster declusterization, as proposed by our hypothesis 4. Finally, as reported by the diagram in figure 8, the limit to growth of the domestic population of finished goods producers, as described by the balancing loop 1^-, is a potential driver of the process of declusterization. In addition, as suggested by our hypothesis 5, the lower the carrying capacity of the domestic market for finished goods, the higher the limit to growth is for the population of finished goods producers and the sooner balancing loop 1^- will kick in triggering the process of declusterization.

By testing a set of hypotheses on declusterization, this paper contributes to three streams of literature. First, as for the literature on clusters/districts, prior researches have explored in a systematic way the impact of clusters on the wealth of nations as well as their economic impact on the geographic area they are located in. A recurring explanation identifies in focal firms, or in other institutions that promote the development of a cluster, the engine of clusters' prosperity. ~~Much~~ L~~l~~ess effort was devoted to~~are the studies that tried to~~ understand the development of clusters' lifecycle adopting an evolutionary perspective (Nadvi, 1999). Our analysis focuses on clusters' decline and death and tries to identify the endogenous drivers of this decline~~ and the actions that can be implemented to invert this trend~~. Is cluster members' internationalization or foreign competition more decisive in explaining declusterization? Our analysis suggests that the two factors may be interrelated. Specifically, the pressure of foreign competition may be amplified by relocation of key competencies from a focal district to a competing foreign cluster. In this respect, the causes of the decline (and the phenomenon that we have named "declusterization") of the clusters must be identified in decisions endogenous to the cluster as well as in competitive pressures. More precisely, it is not only – as it is argued by many studies - that competition from outside threatens consolidated business models; rather, internationalization strategies of a cluster's main actor may as well contribute to, at least partiallyand be stimulated by, to declusterization. In addition, the speed of the declusterization process varies depending on the geographic distance of the countries selected as target markets. In this light, our model suggests that geographical and, more importantly, cultural distance among clusters may inhibit the process of competence delocalization, thereby protecting the cluster that starts to export. However, further studies may empirically test these implications of our model. Another area for further empirical test concerns the analysis of inner dynamics of clusters. Specifically, further studies may investigate whether the declusterization process is characterized by a cycle that involves the various actors of the clusters with a different timing that depends on the role they play within the cluster.

The broader literature on international business, with specific reference to internationalization processes, is a second area of investigation to which our studywe aims to contribute. Mainstream literature tends to describes the internationalization processes as a linear, and incremental and articulated in approach and identifies various phases of the internationalization (Cavusgil, 1982; Johanson & Vahlne, 1977 and 1990; Root, 1998; Wiedershaim-Paul *et al.*, 1978; Chang & Rozensweig, 2001). Most of these studies suggest advocate that internationalization strategies positively affect positively firms' performance and, therefore, consider internationalization is considered as an important driver for companies' growth. We argue that internationalization does not always bring about desirable consequences and may imply trigger counterintuitive long-term consequences. We contribute to this stream of literature by proposing a theory on internationalization processes that focuses its attention on an aggregate of companies (the cluster) rather that the individual firm, as it is in the mainstream literature. In this perspective, ~~Focusing our attention on~~Looking at ~~the flip side of the coin, and, therefore, on the long-~~ ~~term consequences of internationalization strategies,~~ we propose that companies need to coordinate their strategies in international markets and that clusters' sustainability ~~needs to conceive of~~call for coordinating policies able to orchestrate the export of technology and the production of new knowledge~~. For that reason, we propose a nonlinear internationalization process, rather than a linear one, where companies take into account the impact of their own internationalization strategies and their suppliers' internationalization strategies. In this light,~~that ~~companies need to coordinate their strategies in international markets considering the long-term feedback loops that embeds different populations of firms located in the same district~~. ~~Finally,~~ W~~we contribute to this stream of literature by proposing a theory on internationalization processes that focuses its attention on an aggregate of companies (the cluster) rather that the individual firm, as it is in the mainstream literature.~~

As a third area of research, we contribute to ~~the advancement of~~ the research on collective innovation. Specifically, we propose that a Resource-Based View (RBV) perspective provides an appropriate theoretical framework ~~to understand aggregate companies' behavior. In this respect, we add new light to the research on clusters' sustainability. We~~ to argue that the roots of companies' competitive advantage lies in their relationships rather than in the resources and competencies that they possess individually. ~~In this perspective, are~~ Tthe knowledge-based, and trust-based, resources that emerge as the outcome of clusters' members collaboration ~~that~~ contribute the most to companies' competitive advantage. ~~By following this theoretical avenue~~More precisely, we espouse a dynamic interpretation of RBV (Dierickx & Cool, 1989). Specifically ~~For example~~, our simulation study ~~provides an environment that helps to~~ vividly ~~illuminating~~ describes the property of *interconnectedness* among stocks of resources (Dierickx & Cool, 1989: 1508) as a powerful conceptual device that guides researchers to in their investigation of clusters' dynamics.

Finally, under a methodological perspective, we suggest that our work enhances the diffusion of computational approach to theory development in management and strategy research.

At the core is the idea that a computer simulation allows to move between natural to virtual experiments to understand investigate how a causal structure is able to explains empirically observed patterns of behavior (Fioresi & Mollona, 2010). The Simulation experiments allowkey theme here is the ability of a researchers to enact and to maintain a dialogue between theoretical behaviors, as predicted by a simulation built upon accounts from field studies, and observed empirical patterns.

In this light, the use of computer simulation brings about at least twoa number of advantages.

First, in general, eral, computer simulation generates time-series. This may result of some help when time-series can be compared directly with real-world quantitative figures, for example our demographic data. In this case, the availability of real and simulated time series that are accessible in a similar quantitative format facilitates pattern-matching thereby allowing researchers to visually assessing the resemblance between simulated series, which follows from the quantitative simulation of a theoretical hypothesis, and an empirically observed behavior. In this respect, Sscholars may also generate measures of how predicted events match empirical instances of those events (Sterman 1984) as we did in our analysis.

Second, computer simulation allows for a rigorous longitudinal articulation of predicted behaviors. In other words, the computer-aided process of deduction goes far beyond the human capability to appreciate the long-term features of the behavior of selected variables. Thus, computer simulation can support researcher to predict complex patterns of behavior such as peaks and lowest point, oscillations with different characteristics and changes in rates of growth or decline that can be compared with available empirical information.

Third, researchers, by simulating a formal model, can articulate their predictions by contemporaneously producing behavior of different variables and the interactions of these latter, . In particular, researchers can simulate the interaction of independent and dependent variables in each time step, along a given time horizon. This cross-sectional articulation of predictions increases the points of contacts between the theoretical propositions and the empirical world of the case study thereby increasing the opportunities of falsify the model. For example, in our work, we created a new construct – pressures to export – and we developed a hypothesis on the link between thisexports and erosion of finished goods producers. This hypothesis is crystallized in simulated time series (figure 7).

A final remark concerns the generalization of our findings to other empirical contexts. We propose that , under this perspective, our work is tantamount a case study. We used an empirical context to develop a set of hypotheses regarding a phenomenon that, due to it rare occurrence, and often idiosyncratic traits, is hardly amenable to statistic generalization. Rather, we adopted a logic of 'theoretical sampling' (Glaser & Strauss, 1967; Yin, 1994) based on the selection of "extreme cases" or "polar cases". These latter are cases in which the processes of theoretical interest is more transparent than it would be in other cases. More specificallyThus, we selected cases for their 'theoretical relevance', that is, their ability to generate as many properties of the conceptual categories that are the object of our study.

Concluding, wAs Montgomery, Wernerfelt & Balakrishnan suggested long ago (1989), a serious problem that may compromise the quality of theory development in strategy and organization is the looseness and the lack of logical consistency in developing implications from a set of

~~assumptions where "Small changes in assumptions or parameters can alter dramatically the implications of a model." (Montgomery, Wernerfelt and Balakrishnan 1989: 192)~~

~~In this paper, W~~we propose that computer modeling and simulation support theory generation in managerial studies and, in general, in social sciences by contributing to amend for the critical shortcomings that emerge in theory development. Computer modeling, we suggest, forces a researcher to tease out unambiguously her theoretical argument. A simulation experiment entails the formalization of a theory. Formalization enhances simplicity, parsimony, and helps to clarify the morphology and to sharpen the discussion of the theory thereby supporting both its audit trial (Saloner 1994: 170) and ~~its~~ communication.

As any model, the one presented also has limits that reflect its maintained assumptions. On of such limitations is that our calibrations derive from our field analysis. We suggest that our calibrations are plausible. However, further research ought to include in the simulation experiments with different calibration of the model's parameters.

9. References

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Table 1

Calibration of the simulation model

Name	Value	Units
Pop_{m_1}	100	N° firms
Pop_{m_2}	50	N° firms
Pop_{g_1}	100	N° firms
Pop_{g_1}	50	N° firms
g_{m_1}	0.1	Percentage
g_{m_2}	0.1	Percentage
g_{g_1}	0.1	Percentage
g_{g_1}	0.1	Percentage
p_{m_1}	1000	Euro
p_{m_2}	500	Euro
p_{g_1}	5	Euro
p_{g_1}	1	Euro
ϕ	0.3	Percentage

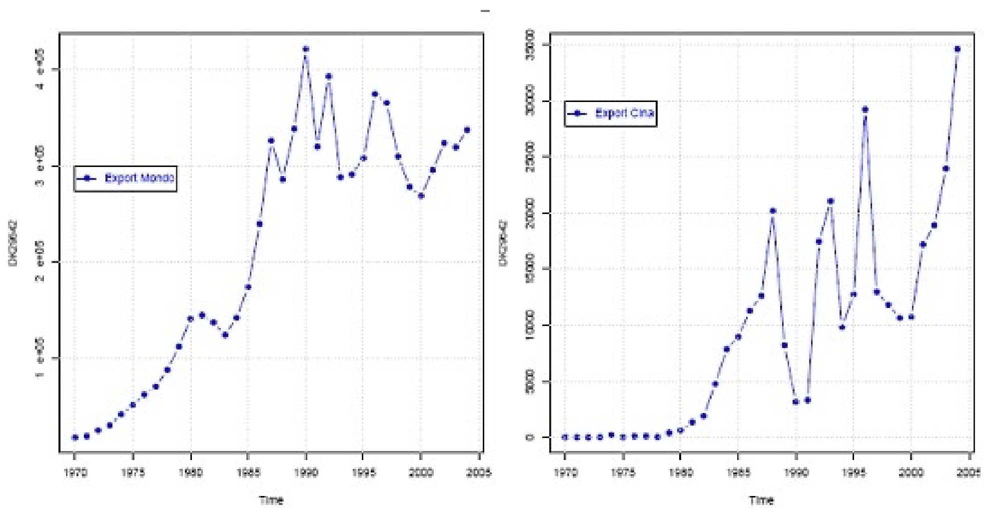

Figure 1
Footwear machineries: world exports (left) and exports to China (right)

146x78mm (96 x 96 DPI)

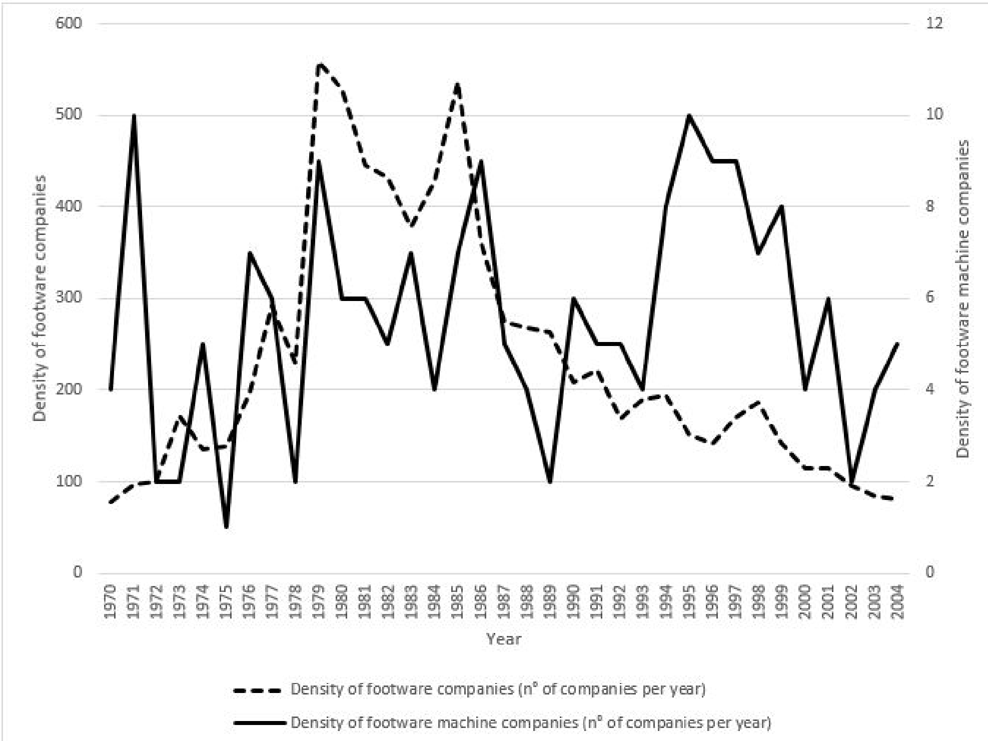

Figure 2 - Exit and density of footwear companies

180x136mm (96 x 96 DPI)

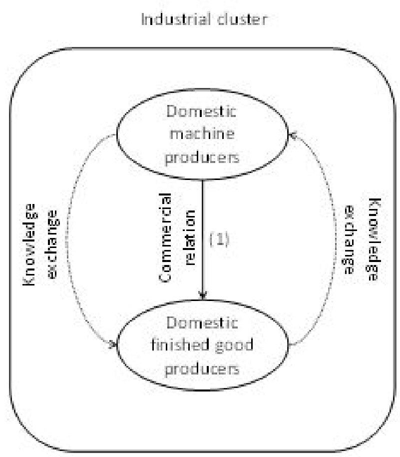

Figure 3 - Within-district knowledge sharing

154x82mm (96 x 96 DPI)

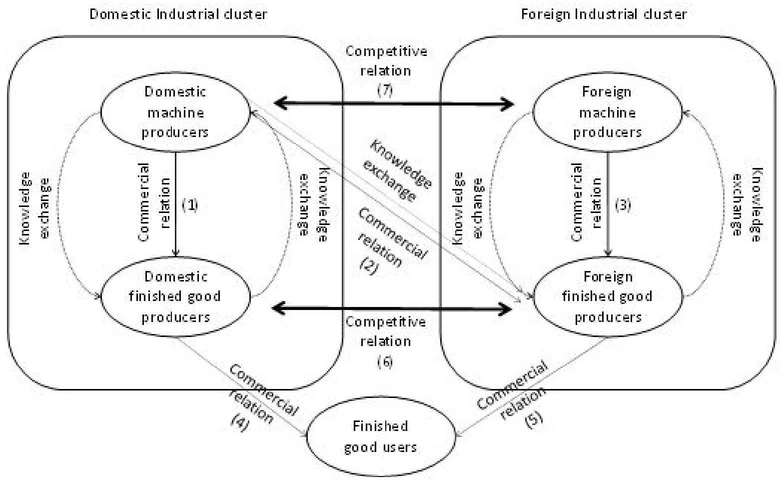

Figure 4 - Cluster emergence and within-cluster development of relational capital

177x97mm (96 x 96 DPI)

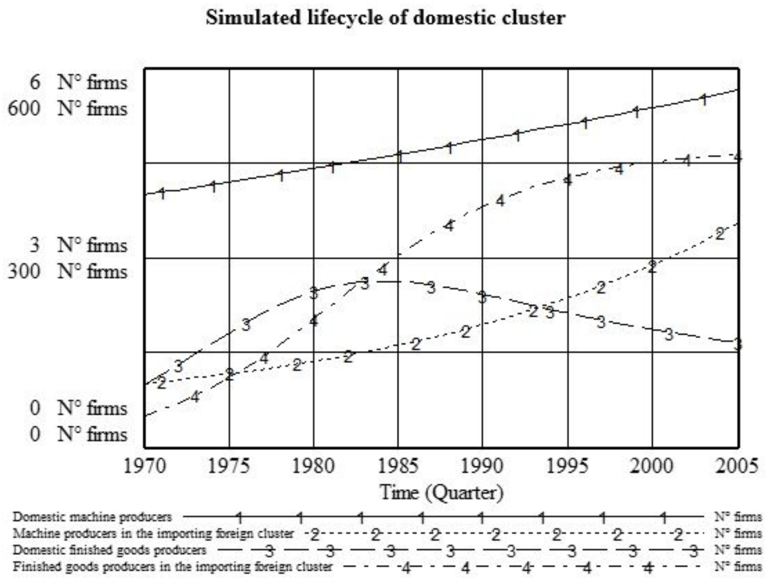

Figure 5 - Simulated lifecycle of domestic cluster

191x129mm (96 x 96 DPI)

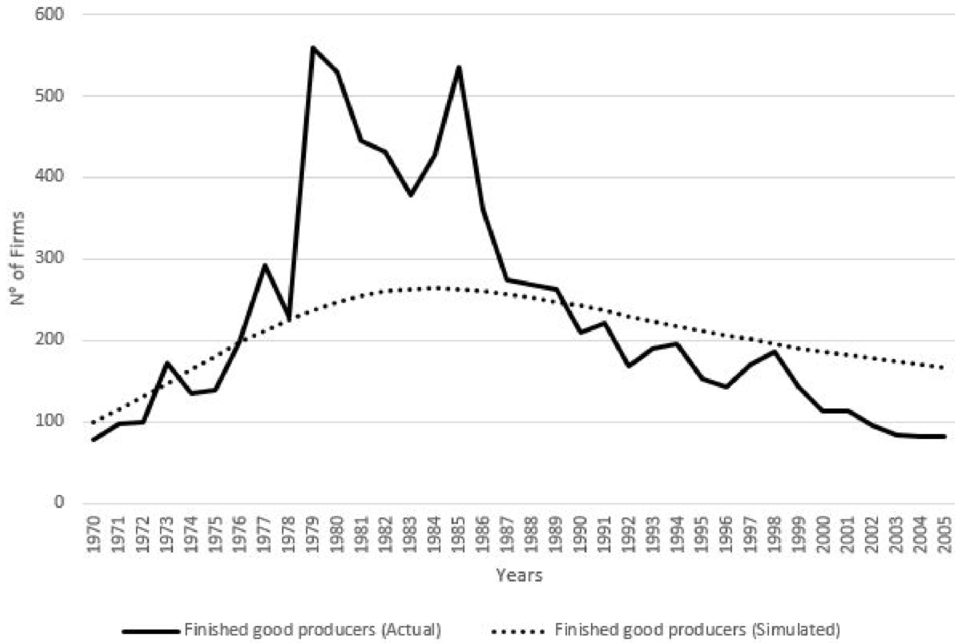

Figure 6 - Declustarization pattern matching

165x107mm (96 x 96 DPI)

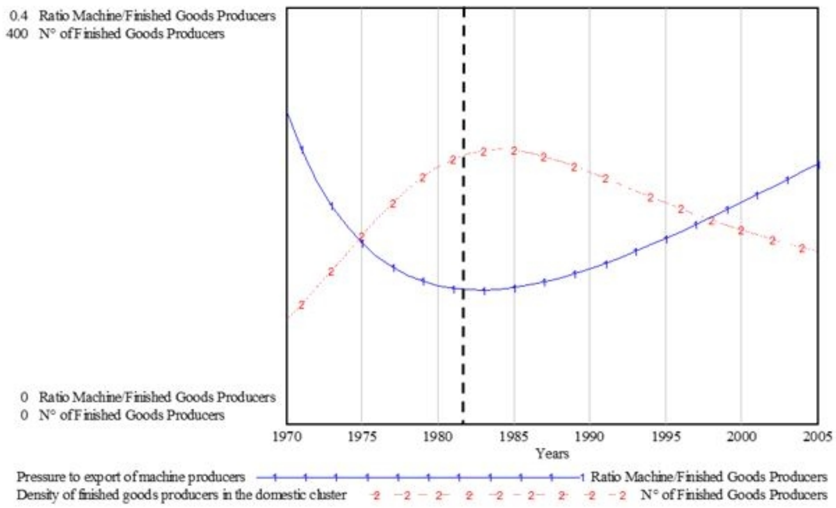

Figure 7 - Simulated pressure to machinery export and finished goods producers' density

189x117mm (96 x 96 DPI)

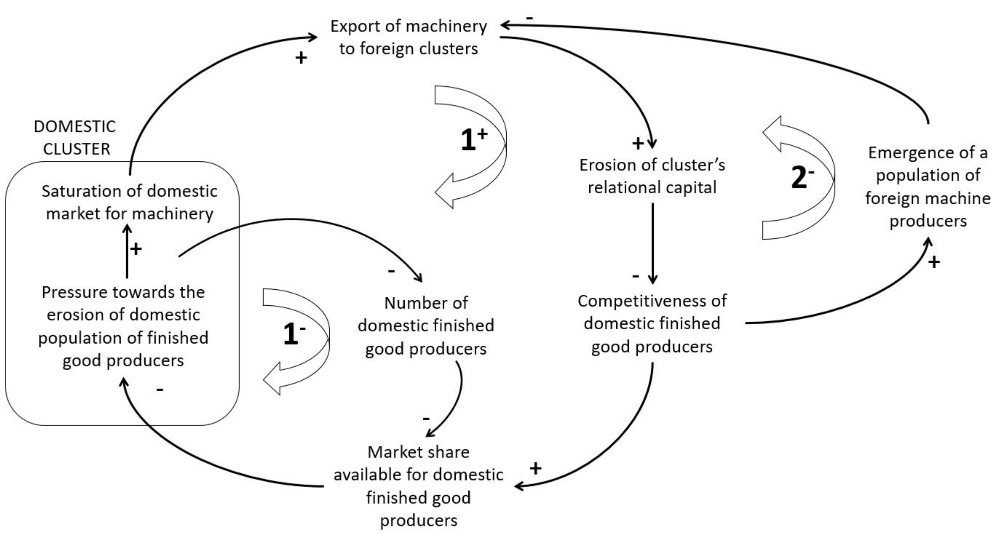

Figure 8 - Feedback analysis of export and declusterization

363x195mm (96 x 96 DPI)