Initiatives and Challenges in the Diffusion of Technological Innovations in the Local Productive Arrangement of Ornamental Stones of Santo Antônio de Pádua – RJ.

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Abstract

The Local Productive Arrangement (APL) of ornamental stones of Santo Antônio de Pádua, located in the northeast region of the state of Rio de Janeiro, is currently the most important productive activity in the region. Despite this, companies make use of simple and rudimentary techniques, which causes serious environmental and competitiveness problems. Aware that the main difficulty faced by this APL is related to the lack of technologies, many research, government and civil society organizations have tried to develop and diffuse technologies in order to enhance the APL's competitiveness. However, some difficulties to diffuse technologies, especially to small companies, have arisen. The objective of this research paper is to identify and describe the factors that hold back technology diffusion. The research study used a qualitative approach and sought to work with multiple sources of evidence such as an extensive bibliographical review, multiple case studies with semi-structured interviews with entrepreneurs and industry professionals, in addition to technical visits to local companies. The elaboration of the data collection instrument was based on the Oslo Manual which categorizes the main barriers of technology diffusion into the following factors: economic, business and others. The results point to problems within the companies such as poorly qualified entrepreneurs and workforce, and their resistance to changes, since financial resources and institutional support for innovation are readily available. The analyses developed in the research study may contribute to the development of a sectoral policy of technology transfer in the Local Productive Arrangement of ornamental rocks.

Keywords: Local productive arrangement (APL); environmental technological innovation; technological diffusion; ornamental stones; public policies.

1 Introduction

The exploitation of stones in the region of Santo Antônio de Páuda, in the northeast region of the state of Rio de Janeiro, is currently the most important productive activity in the region. This sector, according to data from DRM/RJ, comprises about 168 companies (103 quarries, 54 sawmills, 10 sand mines, 1 mineral water source), concentrated mainly in the region of Santo Antônio de Pádua. These companies are responsible for about 5 thousand direct and indirect jobs in the region, which is considered the poorest region in the state of Rio de Janeiro. According to SEBRAE, among the various specialization nuclei operating in the sector of mineral extraction that have been identified in the state, the extraction of ornamental stones in Santo Antônio de Pádua is the most relevant in terms of job generation and income in the local sphere, being very closely resembled to the definition of a Local Productive Arrangement, which is cited in the literature.

In spite of the economic strength of the sector, the mining and cutting operations, in the majority of companies (most of them micro and small sized), make use, until this day, of simple, and even rudimentary techniques, causing uncountable environmental and competitiveness problems. Aware that, even nowadays, the main problems faced by the sector have been related to the absence of technologies for the extraction and refining of stones, several research, government and civil society institutions have

tried to develop and make technologies available that could minimize the sector's problems. From 1990 to the present day, there have been many coordinated and uncoordinated interventions from the institutions of the region and the state, in an attempt to develop technologies which could be implemented in the sector. Many of these technologies may be considered successful, because they were able to solve problems faced by the sector. However, the greatest challenge of the research, government and civil society institutions is to make these technologies available to the majority of micro and small companies, so that the diffusion of technology is performed effectively. Therefore, the research problem raised by this research paper is, given that many specific technologies have been developed and made available for the reduction of problems in the sector of ornamental stones in Santo Antônio de Pádua – RJ, why an overall progress and improvement in the technological situation of the companies is not observed, consequently generating higher productivity in the processes of extraction and refining, better quality products, improvement in the competitiveness of companies and a decrease in the environmental impacts of the activity?

The analyses suggest hypotheses which indicate that these technologies have mainly assisted the large and well organized companies, but their diffusion to micro and small companies is ineffective for many reasons, such as: resistance to make changes in the company and the entrepreneurs lack of access to the research institutions. Another hypothesis raised is that the articulations try to solve specific problems in the supply chain, without using an integrated approach of the activities carried out in the supply chain. Thus, it is possible to identify the lack of a sector based policy regarding the transference of technology to all companies of the sector, in all areas of the supply chain. For that reason, the main objective of this research paper is to identify and to describe the factors that hinder technological diffusion in the Local Productive Arrangement of ornamental stones in the region of Santo Antônio de Pádua, making it difficult for available technologies to reach at micro and small companies of the sector and preventing the sector from becoming more competitive. With regards to the specific objectives, this research paper intends to: describe the traditional processes of extraction and refining of ornamental stones in the region, identify the main problems in all areas of the supply chain; recognize and describe the main technological innovations and their impacts in the sector, as well as identify the ways of articulation of institutions focused on developing them.

2 Methodology

The research study has a qualitative approach since it sought to obtain information and make subjective interpretations about the perspectives of individuals, who in this case, were various entrepreneurs and industry professionals; thereby aiming to interpret the environment of the supply chain and its problematic with regards to the difficulties of the diffusion of technologies. In order to capture the different points of view on the issue in question, the research study sought to work with multiple sources of evidence such as a comprehensive bibliographical review, semi-structured interviews with entrepreneurs and industry professionals and the participation in various technical visits which were carried out in businesses of the region. This multiplicity of sources of evidence turned out to be vital for the reliability of the results. According to Cauchick Miguel (2010), the most appropriate research methods in production engineering to carry out a qualitative research are the case study and the action research. But in the case of this study, the researchers had a low degree of involvement with the individuals and organizations surveyed, thus multiple case studies presented itself as the most appropriate method. The interactions took place during the technical visits, interviews, observations and document consultations. The case study is an empirical study that investigates a given phenomenon resulting from multiple sources of evidence, within a real contemporary context by means of in depth analysis of one or more objects of analysis (cases). (Cauchick Miguel, 2010; Yin, 2001)

The research study began with the definition of a theoretical-conceptual framework by way of a broad bibliographical review composed of articles and technical publications regarding the sector of ornamental rocks, so as to describe the processes of companies and their problems, the innovations and technologies developed and available to businesses, as well as their impact on the sector. Next, a sample of 20 cases

(20 small businesses from a population of 54 legal sawmills) were selected, from which data was collected (qualitative data) through structured interviews conducted in technical visits and analyses of the production processes. The focus of the investigation was to identify the main factors that hinder the absorption of technological innovations by firms. The elaboration of the data collection instrument was based on the Oslo Manual (2011) which categorizes the main barriers of technology diffusion into the following factors: economic, business and others. At the end of the analysis of the information obtained from multiple cases, it was possible to identify the causes that hindered technological diffusion in the industry, hence allowing a greater generalization of the results. Furthermore, this information was corroborated by other sources of evidence such as the extensive bibliographical review and technical visits.

3 The Supply Chain of Ornamental Stones in Santo Antônio de Pádua – RJ and the Environmental Impacts of the Activity

3.1 The traditional processes of extraction and refining

The traditional processes of extracting and refining rocks for the production of ornamental stones in the municipality of Santo Antônio de Pádua, that remain in all companies of the region, even those that have acquired new equipment and have implemented innovations, is still little mechanized and mostly handmade. The first activity of the process is the extraction of blocks of rock from the field. The basic extraction technology employed by the majority of companies consists of the detonation of the bedrock, which is very often done rudimentarily (by trial and error), which reduces the economical value of the blocks, because they may present cracks and not uniform edges, and causes severe environmental damages. In a second phase of the extraction, a worker, with the aid of a sledgehammer and chisel, removes small blocks of 50cm x 50cm x 40cm size from the bigger blocks. After the extraction of these small blocks, they are manually sliced into plates by a worker, with the aid of a sledgehammer and a chisel. The stone plates are then transported by truck to the refining companies where they are cut with small saw machines, equipped with a diamond disk, into the fine dimensions of an ornamental stone. Finally, these little plates are once again sliced manually. This procedure produces the end product – the plates of ornamental stone. After the refining, the products generally a commercialized by companies in the region are: Plate, 47 x 47 x 4 cm; Block, 23 x 11.5 x 4 cm; and Brick, 23 x 11.5 x 1.5 cm, or 11.5 x 11.5 x 1.5 cm.

3.2 The Severe Environmental Problems Caused by the Traditional Processes

As previously mentioned, due to the lack of technology in the processes described above, the loss of raw material is very high throughout the supply chain. During the extraction the loss might be of about 30%. Besides the economic losses, the loss at this point of the process causes irreversible and severe environmental impact. Once the rocks have been extracted, the extraction area becomes useless, with no alternative use, since the stones are spread on the entire area. During the refining, the problem is even bigger. The loss of raw material may reach 50%. The result of this problem is mountains of debris irregularly disposed in abandoned lands beside the roads of the region. Also during the refining, besides the loss of raw material, there is the release of dust from the stones from the saw machine. This dust, with a very fine granulometry, is inappropriately disposed together with the water used in the process, as mud.

According to Ribeiro, Correia and Seidl (2005), this mud is mostly constituted of water, grit, lime and smashed rock (aluminosilicates, feldspar and quartz), which after the process are disposed in the environment. After the evaporation of the water, the resulting dust spreads, contaminating the air and the water resources. In some cases, the resulting mud is directly channeled to rivers and lakes, causing a serious environmental problem. These serious and recurring environmental problems have caught the authorities' attention since the 1990s. The authorities, through environmental laws, started to fine and close the sawmills and quarries which disposed their rejects inappropriately in the environment.

4 The Technological Innovations in the Sector and Their Benefits for the Productive Activities and the Environment

The process of meeting and supporting the manufacturer of ornamental Stones in the region of Santo Antônio de Pádua began in the late 80's, by DRM-RJ (Departamento de Recursos Mineirais do Rio de Janeiro). At that time, the non-articulate action of institutions and local government did not help to minimize the problems in the sector, mainly due to the great expansion in the quantity of production areas and the addition of young miners to the business; all similar to the mining phenomenon. Thus, the implementation of technological innovations was scarce till the mid 90's.

Back in that time, the Serviço Brasileiro de Apoio às Micro e Pequenas Empresas (SEBRAE–RJ) and the Associação de Empresas de Pedras Decorativas (AEPD) were able to sign a contract with the Centro de Tecnologia Mineral (CETEM) in order to try to solve the problems that companies in the region were facing (Almeida, Chaves and Leal Filho, 2001). From the problems diagnosed, the Centro de Tecnologia Mineral (CETEM) developed works for the improvement of the production of the quarries, especially the aspects related to the extraction of rocks, the safety of workers and the treatment of effluents. These actions, though considered of low impact by some entrepreneurs of the sector, were continued in the project Rede de Tecnologia Mineral – RETECMIN. According to Silva and Margueron (2002), the RETECMIN, was a technology cooperative network for the "support of the Productive Sector of ornamental Stones in the state of Rio de Janeiro". This network included: DRM (Departamento de Recursos Minerais), INT (Instituto Nacional de Tecnologia, UENF (Universidade Estadual do Norte Fluminense), UFRJ (Universidade Federal do Rio de Janeiro), CETEM (Centro de Tecnologia Mineral) and FIRJAN (Federação das Indústrias do Estado do Rio de Janeiro). Despite the broad articulation, the RETECMIN was largely criticized by some entrepreneurs for not providing quick and practical results.

Another institution which intervened in the sector in the late 1990's, not articulated with RETECMIN, but with other agencies like SEBRAE, FINEP and FAPERJ, was the ETFC – Escola Técnica Federal de Campos, currently known as IFF – Instituto Federal Fluminense.

Therefore, after the effort to identify the main problems of the sector, several applicable researches have been developed by institutions of the region aiming to find viable alternatives for the use of residues of the extraction and refining processes of the ornamental stones and for the improvement in the competitiveness of the companies. The technological innovations made available through those researches and to be used in the supply chain of ornamental stones in Santo Antônio de Pádua can be organized according to Figure 1.

Segregation of fine solids (Effluent Treatment Units) and their use in mortar for Construction (Mortar Factory)

One of the first and most important projects, within the associations of RETEMIN, was the "Segregation of fine solids and their use in mortar for construction", a technology developed by CETEM which proposes the use of fine grained gneiss in the production of mortar. In the first phase of the project, CETEM elaborated a system for the treatment of liquid rejects in order to avoid the disposal of such rejects into the rivers of the region of Santo Antônio de Pádua. The cutting equipment of the companies were, and still are, obsolete since they do not take into consideration the capture and reutilization of water and the fine rejects of the slicing process of stones. These became one of the main legal/environmental problems, due to the intervention of the Public Ministry. At this phase, according to Peiter (2000), RETECMIN was very successful for establishing a simple and low cost process for the collection, cleaning and recycling of water originating from the sawmills – the effluent treatment units, also known as settling ponds.

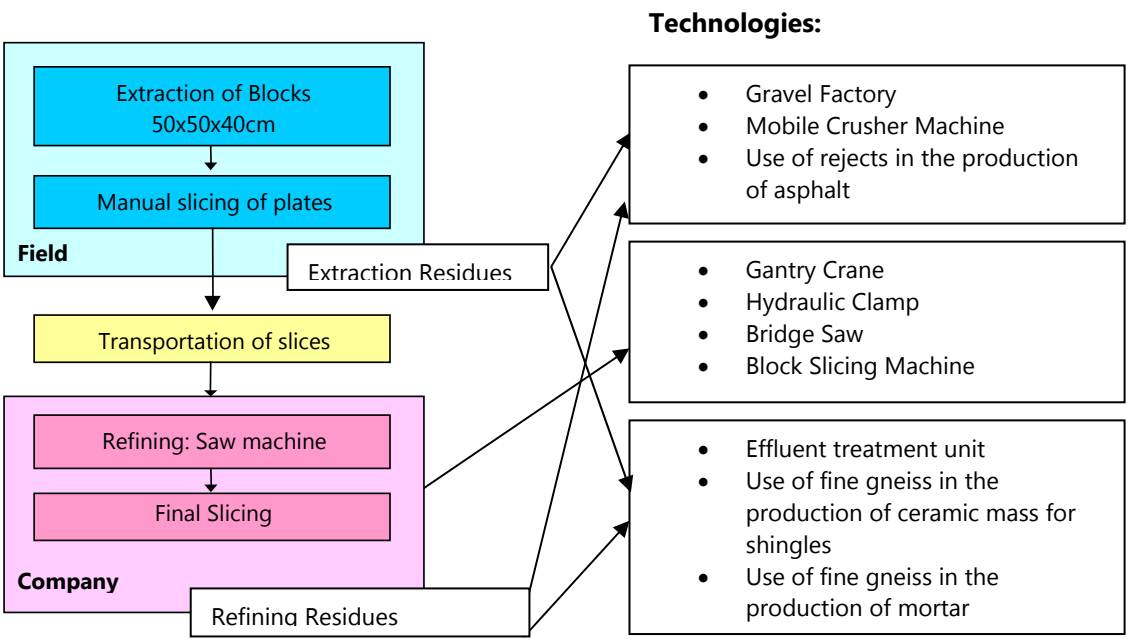

Figure 1: Available Technologies for the supply chain of Ornamental Stones in Santo Antônio de Pádua.

In the second phase of the project, the researchers searched for alternative uses for the fine solid rejects resulting from the first phase of the project. The results demonstrated that the fine grained gneiss could be used as an alternative to lime in mortar production, a solution achieved by CETEM along with Universidade Estadual do Norte Fluminense (UENF), in Campos dos Goytacazes – RJ. The research resulted in the patent PI0205481-7. With new funds, the technical project and the feasibility study for the implementation of a mortar factory which should consume all the mud resulting from the sawmills in Santo Antônio de Pádua were carried out. The study demonstrated the investment's feasibility and caught the attention of the local community and Public Ministry, for the promise of lowering the level of pollution of the Pomba River, which is usually harmed by the disposal of residues (PEITER, 2000). Thus, after the demonstration of the feasibility of the project and with the support of INVESTRIO, the institutions were able to convince a private group of the region, Mil Group, to invest in the construction of a mortar factory, ARGAMIL, which is still operating by collecting fine residues of several sawmills and recycling them into mortar.

The use of fine grained gneiss in Ceramic Mass for Shingles

Also aiming at recycling the residues from the sawmills previously mentioned, and within the sphere of action of RETECMIN, a new proposal was made for the use of stone dust in the ceramic mass for the production of shingles. The work of Vieira, Henriques, Peiter, Carvalho, Monteiro (2006) aimed to evaluate the effects of substituting sand with fine graned gneisse, which is a residue of the refining process, in a red ceramic mass used in the manufacture of shingles. The results showed that the fine grained gneiss can easily be used in the composition of the red ceramic mass. The greater mechanical resistance of such a ceramic is the main justification for its use instead of sand.

The use of residues from the sawmills in asphalt production

Once again, based on the attempt to recycle the residues from the sawmills previously presented, but outside the sphere of action of RETECMIN, there was a proposal for the use of this abundant mineral residue in the production of asphalt. According to Elphingstone (1997) and Franquet (1999) *apud* Ribeiro, Correia and Seidl (2005), the asphalt used for paving consists of, generally, 95% of mineral aggregates (generally basalt gravel and sand) and 5% of petroleum asphalt cement (CAP). Based on these considerations, the project's objective was to replace the mineral aggregates usually used in asphalt with residues generated in the extraction and refining of ornamental stones, through crushing and screening. Therefore, there was an intention to reduce the costs of asphalt production and, more importantly, diminish the environmental impact caused by those residues. The project's results, according to Ribeiro, Correia and Seidl (2005), indicate that the mineral rejects produced by the quarries and sawmills of

ornamental stones of the region, if properly crushed and screened, could be used in paving asphalt instead of the commonly used aggregates, thus reducing the costs of production and decreasing the environmental impacts.

The Gantry Crane, the Hydraulic Gripper and the Bridge Saw

Another important public intervention in the sector, also outside the sphere of articulation of RETECMIN, happened in the late 1990's, when the so called ETFC – Escola Técnica Federal de Campos, nowadays known as IFF – Instituto Federal Fluminense, supported by SEBRAE and FINEP through the "Programa de Apoio Tecnológico a Micro e Pequena Empresas" (PATME), developed, for a consortium of entrepreneurs, a group of equipment which allowed a new layout and a new physical arrangement for the unloading of the blocks removed from the field and taken for refining in the sawmills. The first equipment was the Gantry Crane, used to unload blocks from the truck and move them transversally, longitudinally and vertically. In order to develop a gantry crane able to comply with the technical demands of unloading and cutting blocks of ornamental stones, a technological innovation was required – the "Hydraulic Gripper", a mechanism able to unload large blocks of ornamental stone (SILVA NETO, 1990). Yet, in the sawmill, another innovation adopted by the consortium of companies, was the importation of a circular saw of high precision, also known as bridge saw, which is able to cut large blocks of stone. (SILVA NETO, 1990). After the implementation of such equipment, the whole extraction and refining processes was revolutionized, because the unloading of blocks from the trucks and their placement upon the bridge saw, by means of the hydraulic gripper, allowed the companies some other benefits.

Gravel Plant which uses crushed rejects from the quarries and sawmills

The rejects of quarries and sawmills, as mentioned before, are inappropriately disposed along roads or in abandoned lands, causing a significant environmental impact. A technically viable alternative for the use of such rejects consists in crushing such material so as to produce aggregates for construction: gravel stone, sand and dust. In 2010, supported by the Serviço Nacional de Aprendizagem Industrial (SENAI) and funds from FAPERJ, a Gravel Plant was installed close to the Raio do Sol Sawmill, on the road between Santo Antônio de Pádua and Paroquena, (Km 04), which belong to Mr. João Luíz Nacif. After crushing the rejects, three materials are produced: Gravel 2, which is mainly used in asphalt cement, Gravel 1, which can be used in cement, asphalt and precast, and stone dust, usually used in the production of mortar and precast. The results of analyses, according to the mentioned authors, suggest that the material is suitable for construction, even though it is limited to small and medium sized constructions.

The mobile crusher machine

Another initiative of IFF – Instituto Federal Fluminense, which took place in 2010, was the development of the mobile crusher machine with funds of FAPERJ, through the Technological Innovation Announcement 2010. According to Silva Neto (2012), the project aimed to project, develop and build a mobile crusher machine which should be able to process residues originating from both the extraction and refining processes, complying with the technical characteristics of the rocks of the region, with the objective of producing material suitable for paving country roads of the region. A set of equipment was assembled upon a chassis for the crushing process. In this process, the residues/stones enter through a vibrating feeder which constantly supplies a jaw-like crusher. The crushed material is then placed onto a conveyor belt and guided to a truck so it can to be transported to another location. This processing of residues, which changes them into sub products for paving, reduces environmental impacts originating from residues disposed at different locations of the region and also increments the availability of raw material for paving the country roads.

The greatest advantage of the mobile crusher machine in face of the Gravel Plant is that the equipment can be transported to the places where the residues are deposited so as to crush them at the same location, and placing them close to where they will be used, thus decreasing the costs of transportation. In the Gravel Plant, on the contrary, the transportation costs are higher, once the trucks must go to the places where the residues are located, collect and take them to the plant, and only after being crushed, can the material be relocated to its destination.

The slab opener

This ongoing project, is another initiative of IFF – Instituto Federal Fluminense and is also supported by FAPERJ, through the Technological Innovation Announcement 2011, which aims to project, develop and build a "Hydraulic Machine able to slice Ornamental Stone" with the objective of increasing the productivity, reducing waste and improving the quality of end products of the ornamental stone industry of the municipality of Santo Antônio de Pádua. The results expected from this equipment, which is still being developed, are: an increase in productivity of plates, once this process will be performed by a modern and precise equipment; reduction of waste, once most of the handmade cuts will be avoided, causing a reduction in the amount of rejects; and consequently, the reduction in the environmental pollution (SILVA NETO, 2011). This equipment is considered by the entrepreneurs as the most important innovation for the sector, because currently the main problem faced by the companies is the lack of specialized workforce able to open blocks into slices. According to the entrepreneurs, this activity, historically, used to be performed by teenagers who would learn the work from a young age. But, due to the efforts of the Work Ministry which has enforce the prohibition of child labor, this "training" of kids is not allowed and has caused a scarcity of specialized labor. Therefore, the most important problem in the supply chain of ornamental stones lies in the last activity performed, the slicing of plates, which demands a very specialized workforce.

5 Innovation and Technological Diffusion – Challenges for the Local Productive Arrangement of Ornamental Stones of Santo Antônio de Pádua.

A Local Productive Arrangement (APL), according to Lastres & Cassiolato (2005), is defined as a territorial agglomeration of economic, political and social agents - with focus on a specific set of economic activities - which have links, even though they may be incipient. It usually involves the participation and interaction of companies - which can range from producers of end products or services, all the way to suppliers of inputs and equipment, consulting companies, service providers, distributors, among others - and its various forms of representation and association. It also includes several other public and private institutions focused at training human resources, such as technical schools and universities; research, development and engineering; policy, promotion and funding. When a productive arrangement evolves into a relationship of consistent interdependence, articulation and linkages that result in interaction, cooperation and learning, with the potential of generating increased endogenous innovative capacity, competitiveness and local development, it becomes a Local Productive and Innovative System (LPIS).

Lastres & Cassiolato (2005) highlight innovation and interactive learning as one of the main features of LPAs. They are a key source for the transmission of knowledge and the expansion of the capacity of production and innovation of companies and other organizations. They allow the introduction of new products, processes, methods and organizational formats, being essential for the assurance of sustained competitiveness of the different local players, both individually and collectively. Although several efforts have been developed, the LPA of ornamental stones of Santo Antônio de Pádua, is not yet an LPIS, given that the governance system is not essentially cooperative. It is necessary to build a structure of relationships between the agents involved in the activities of the arrangement. The agents still do not share history, standards and common values that facilitate the development of social capital and act as a buffer; a control of opportunistic or malicious behavior.

The Technological Innovation increasingly assumes the role of the key-resource in the organizations and a source of a competitive advantage. Mueser (1985) defines technological innovation as "a new idea, a discontinuous technical event, which after a certain period of time, is developed until the time comes in which it becomes handy, and is then used successfully." On the other hand, Rothwell and Gardiner (1985) point out that innovation does not necessarily mean the commercialization of only major technological advances, but also includes the use of small-scale changes in technological knowledge. Utterback (1983), suggests that technological innovation is understood as a process that involves the creation, development, use and dissemination of a new product or idea, or the introduction and diffusion of new

products and processes which have improved in the economy. Nevertheless, a Technological Diffusion can be conceptualized as the process by which an innovation is communicated over time, through certain channels, among members of a social system (Rogers and Schoemaker, 1971). However, Tigre (2006) states that "the processes of innovation and diffusion cannot be completely separated, because in many cases diffusion contributes to the process of innovation". To meet the objectives of this research paper, it is important to identify what factors harm the diffusion of innovations in the LPA of ornamental stones of Santo Antônio de Pádua. The Oslo Manual (2011) declares that the major obstacles to technological diffusion are the following factors:

Table 1: Major obstacles to technological diffusion by Enterprises

Economic Factors	**Enterprise Factors**	**Other reasons**
• excessive perceived risks; • very high costs; • lack of appropriate sources of finance; • long pay-off period of innovation	• innovation potential (R&D, design, etc.); • lack of qualified workforce; • lack of information on technology; • lack of information on markets; • innovation expenditure hard to control; • resistance to change in the company; • deficiencies in the availability of external services; • lack of opportunities for cooperation.	• lack of technological opportunity; • lack of infrastructure; • no need to innovate due to earlier innovations; • weakness of property rights; • legislation, norms, regulations, standards, taxation; • customers unresponsiveness to new products and services.

Source: Oslo Manual (2005)

Based on the technical visits and the interviews with entrepreneurs of the sector and with professionals of the supporting institutions, it became evident that despite all of the efforts of the institutions to raise funds and to develop technologies to minimize the problems of the sector, these are not widely widespread. As shown in Table 2 below, the Enterprise factors, especially the lack of qualified workforce, lack of market information and the resistance to changes in the company, were the main obstacles to the technological diffusion in the sector. In some cases, the Economic Factor, 'too expensive', was a barrier to diffusion.

Table 2: Diffusion of the Technologies by Companies

Technology	Number of Companies which adopted the technology	Obstacles for Technological Diffusion	Comments
Effluent treatment unit	47	No obstacles	The great adherence to the technology is justified by the obligation imposed by the Term of Conduct Adjustment of the Public Ministry
Use of fine grained gneiss in mortar for Civil Construction	1 factory producing mortar	No obstacles	The great adherence to the technology is justified by the obligation imposed by the Term of Conduct Adjustment of the Public Ministry
Use of fine grained gneiss in ceramic shingles	0 (zero)	Economic factor: - very high cost	Although the technical feasibility has been established, the cost of transportation is not economically feasible for the use of the residue by the ceramic shingle producers in the region.
Gravel plant for the use of rejects in civil construction or in the production of asphalt	1 enterprise built the Gravel Plant	Economic Factors: - very high cost - excessive perceived risks Enterprise Factors: - lack of qualified workforce - lack of information on markets - resistance to change in the company	The high investment costs associated with the low qualification of entrepreneurs and their employees do not allow them to identify market opportunities or take risks on new business ventures.
Gantry Crane	2	Economic Factors: - very high cost Enterprise Factors: - lack of qualified workforce - resistance to change in the company	Only two companies in the region have this type of equipment to assist the processing of ornamental stones. The high cost of equipment and the lack of qualified workforce for its operation are limiting factors for its dissemination among companies in the region.
Hydraulic Gripper	1	Economic Factors:	Only one company in the region has this type of

		- very high cost Enterprise Factors: - lack of qualified workforce - resistance to change in the company	equipment to assist the processing of ornamental stones. The high cost of equipment and lack of qualified workforce for its operation are limiting factors for its dissemination among companies in the region.
Bridge Saw	2 (operating) and 1 (being installed)	Economic Factors: - very high cost Enterprise Factors: - lack of qualified workforce - resistance to change in the company	Only three companies in the region have a bridge saw or a circular saw. The high cost of equipment, which is imported, is a limiting factor for its dissemination among companies in the region
Mobile Crusher Machine	1	Economic Factors: - very high cost - excessive perceived risks Enterprise Factors: - lack of qualified workforce - resistance to change in the company Other factors: - lack of technological opportunity	Only one company owns the mobile crusher machine. The equipment was built with public funds (FAPERJ). The difficulty in most companies approaching the research institutions is a factor that limits the spread of such support.
Slab Opener	3 (entrepreneurs are interested)	The equipment is still being developed with public resources (FAPERJ).	This equipment is in the same situation as the Mobile Crusher Machine. The equipment was built with public funds (FAPERJ).

Source: Technical visits with entrepreneurs and professionals in the sector

However, obstacles such as lack of appropriate funding, hard to control expenditures on innovations, insufficient innovation potential, or even a lack of technological opportunity were not observed during the interviews and technical visits. These results indicate that there is broad availability of public resources for technological innovation, as well as the capacity and initiative on the part of research institutions to develop technologies for companies. Therefore, the survey results point to the need for interventions to be made in the companies, in view of the fact that the Company Factors were the main obstacles to the diffusion of technology. In particular, one can highlight the need to increase the level of education and qualification of entrepreneurs and workforce in the sector, as well as to provide specific training with regards to technological innovation. This is the only possible way to make innovations available to the micro and small companies of the sector.

6 Conclusion

It is believed that if the innovations presented in this research paper are properly diffused to other companies in the sector, they can lead to significant advances in quality, productivity and competitiveness in the sector in a generalized form, consequently raising the technological level of the sector. Moreover, there is a guarantee of low production of waste and effluents in the production process, guaranteeing a lower rate of environmental pollution. However, great difficulty to diffuse the technology was found. Thus, the study sought to identify and describe the factors that withhold the diffusion of technology. Factors that make it impossible for this technology to reach micro and small companies in the sector, and prevent the increase of the sector's competitiveness.

The results of the analyses results showed that the main obstacles to technology diffusion in the sector were the Company factors, especially the lack of qualified personnel, lack of market information and the resistance to changes in the company. In some cases, the Economic Factor 'too expensive' was also a barrier to diffusion, but because of the availability of several lines of credit to entrepreneurs, this factor cannot be regarded as decisive.

Therefore, the research study sought to describe the scenario for the development of a sectoral policy of technology transfer to reach the micro and small enterprises of the sector at all stages of the supply chain. In particular, it is possible to deduce from the analyses carried out that, among the various sectoral policy actions that could be taken, the need to increase the level of education and qualification of the

entrepreneurs and workers in the sector, as well as the need to implement specific training with regards to technological innovation, are priorities. Also, it is necessary that the elements involved in the supply chain attempt to solve the problems in the supply chain by means of an integrated view of the activities and through a system of cooperative governance. Only then is the Local Productive Arrangement likely to become a Local Innovation and Production System and the sector can increase its level of competitiveness.

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