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ENVIRONMENTAL PERFORMANCE AND ECONOMIC FEASIBILITY IN AN INTERLOCKING CONCRETE PAVING INDUSTRY

DESEMPENHO AMBIENTAL E VIABILIDADE ECONÔMICA EM UMA INDÚSTRIA DE PAVIMENTOS INTERTRAVADOS

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Adriana Ireno de Souza[1]
Leonardo Alves de Oliveira Casimiro[1]
Emanuel Campigotto Sandri[2]
Jerry Adriani Johann[3]
Geysler Rogis Flor Bertolini[4]

1 Universidade Estadual do Oeste do Paraná (UNIOESTE), Programa de Pós-Graduação Em Administração (PPPGA), Mestrado Profissional, Cascavel, Paraná, Brazil.
2 Universidade Federal do Paraná (UFPR) Programa de Pós-Graduação Em Administração (PPPGA), Doutorado em Administração, Curitiba, Paraná, Brazil.
3 Universidade Estadual do Oeste do Paraná (UNIOESTE), Centro de Ciências Exatas e Tecnológicas, Campus de Cascavel. Cascavel, Paraná, Brazil.
4 Universidade Estadual do Oeste do Paraná (UNIOESTE), Centro de Ciências Sociais Aplicadas, Campus de Cascavel. Cascavel, Paraná, Brazil.

ABSTRACT

Purpose – This study's main objective is to verify if there is a relation between proactivity and technological protection in the environmental performance of the ventures in this segment. And check if there is economic feasibility to produce interlocking concrete paving blocks with the addition of rubber, as well as the certification of the product as ecologically friendly.
Design/methodology/approach – The study is based on the methodologies shown by Dickel (2017), questionnaire and variables, and Bertolini (2009), economic viability for the manufacture of ecologically friendly products.
Findings – As a result, the study confirms the association between technological protection and proactivity in environmental performance, as well as the economic viability for the offer of the interlocking concrete paving product with ecological certification.
Originality/value – Civil construction occupies a prominent position, accounting for a significant portion of Brazil's Gross Domestic Product (GDP), as well as being the largest employer industry in the country. It is also recognized as having significant environmental impacts in the conduct of its activities. However, the search for sustainability has been a mobilizing element in the definition of corporate strategies, companies have been seeking more and more actions that are economically viable, respecting environmental and social aspects.
Keywords: Sustainability. Civil construction. Environmental performance. Economic viability.

RESUMO

Objetivo – O presente estudo tem como objetivo, verificar se há relação entre proatividade e proteção tecnológica no desempenho ambiental dos empreendimentos nesse segmento. E verificar se existe viabilidade econômica para a produção de pavimento intertravado com a adição de borracha, assim como a certificação do produto como ecologicamente correto.

Design / metodologia / abordagem - O estudo tem como base as metodologias apresentadas por Dickel (2017), questionário e variáveis, e Bertolini (2009), viabilidade econômica para a fabricação de produtos ecologicamente correto.

Resultados - Como resultado, o estudo confirma a associação entre da proteção tecnológica e da proatividade no desempenho ambiental, assim como a viabilidade econômica para a oferta do produto pavimento intertravado com certificação ecológica.

Originalidade / valor - A construção civil ocupa uma posição de destaque, sendo responsável por uma significativa parcela do Produto Interno Bruto (PIB) brasileiro, além de ser a maior indústria empregadora do país. Também é reconhecida por deflagrar significativos impactos ambientais na condução das suas atividades. No entanto, a busca pela sustentabilidade tem sido elemento mobilizador na definição de estratégias corporativas, as empresas têm buscado cada vez mais adotar ações que sejam economicamente viáveis, que respeitem aspectos ambientais e sociais.

Palavras-chave: Sustentabilidade. Construção civil. Desempenho ambiental. Viabilidade econômica.

1 INTRODUCTION

Civil construction holds a prominent position in the Brazilian economy, being responsible for a significant portion of the Gross Domestic Product [GDP]. According to the Brazilian Institute of Geography and Statistics [IBGE] (2017), the sector accounted for 5.1% of the country's total GDP in 2016, and about 15% of the industry GDP in the same year. The contingent of labor employed in civil construction deserves to be highlighted, as it is considered the largest employer industry in the country, accounting for about 5% of formal employment and 6.5% of the total workforce in the country (formally or informally).

The production chain of civil construction has been causing a major environmental impact due to its particularities, which become significant on a global scale, among the direct impacts, the generation of waste can be cited, which reaches 40% of the total waste generated by society (Vechi, Gallardo, & Teixeira, 2016). The inadequate disposal of waste is one of the main causes of environmental degradation, this situation affects the quality of life of the population, ecosystems and the availability of natural resources. Some environmental practices already adopted in the civil construction sector have been contributing to issues related to impacts on the production chain, such as the use of water, energy and the generation of waste itself (Silva, Vaz, Barbosa, & Lintz, 2017).

According to Barbieri (2004), the role of companies in promoting development that respects the environment, not only aims to solve the environmental problems accumulated over the years as a result of their activities, but also to expand its influence in all fields of human activity. The search for alternative materials is a technological and ecological option to minimize environmental degradation by reducing waste, costs and improving performance, seeking to reach potential customers who may consider this factor in the purchasing process (Barbosa, Pereira, Akasaki, Fioriti, Fazzan, Tashima, & Melges, 2013; Santos, Teixeira, Kniess, & Barbieri, 2016).

Despite greater awareness and environmental concern at a global and national level, the Brazilian civil construction industry is still far from what would be a process that develops ecologically friendly products for the consumer market. Except for some initiatives such as legislative norms for the separation and recycling of rubble (National Environment Council [CONAMA], 2002), the sector can be classified as traditional and reticent to the needs of greater ecological conservation (Stachera, 2006).

In a new context of growing concern about sustainability, it is necessary to redefine the product, so that potential customers can consider it in the purchasing process, not only the tangible product, but also the organization's concerns regarding environmental responsibility (Peattie & Crane, 2005). An organization cannot be considered sustainable if the products manufactured, sold or services provided do not respect the principles of sustainable development.

In this regard, the Institute for the Development of Ecological Housing [IDHE] (2017) defines ecological materials as articles and/or consumer goods prepared without harming the environment and the health of living beings, from the use of natural raw materials that are renewable or non-renewable, but that they can be reused, recycled or which cause the minimum impact during their manufacturing process and after use.

Interlocked pavements, as described in NBR 9781 of the Brazilian Association of Technical Standards [ABNT] (1987), are precast concrete pieces used in the construction of pavements or sidewalks. Its main characteristics are the fact that the pieces are simply seated and permeable, as they allow passage for part of the rainwater to seep to the ground through the joints.

According to Hallack (2001), the paving technique with cement-based blocks appeared in Brazil in the 1970s, still very incipient and many times without obeying minimum technical criteria. The demand for sustainable works in the civil construction market has been calling for alternative methods that allow for sustainable construction, based on economy and rationality. Currently, this type of paving is found in urbanization programs, in decrees and laws, which are major allies in encouraging the use in areas of public sidewalks.

In this sense, it can be seen that the studies dealing with interlocked paving as an ecological product had as its central objective the use of ecological materials in this type of pavement at a theoretical level (Medineckiene, Turskis, & Zavadskas, 2010; Santiago & Dias, 2012; Dickel, 2017), as well as at the empirical level, through tests and surveys on the replacement of components (Collins, Hunt, & Hathaway, 2008; Barbosa *et al.*, 2013; Costa, Gumieri, & Brandão, 2014; Dias, Menegazzo, Quinteiro, & Serafim, 2016; Silva *et al*., 2017; Kleijer, Lasvaux, Citherlet, & Viviani, 2017). Highlighting a research gap regarding the analysis of economic feasibility with regard to the manufacture and marketing of this product, as well as the life cycle and its environmental impact in the long term, enabling to control and measure how positive or negative the use of this type of material is for the environment and society.

Thus, the problem arises in the following question: based on the effects of technological protection and proactivity in the environmental performance of organizations, is there financial viability for investment that seek to make the product of an interlocked pavement industry ecologically friendly? First, the objective of this study is to verify the effects of proactivity and technological protection on environmental performance, based on the perception of customers. And later, to verify if there is economic feasibility to produce interlocking concrete paving blocks with the addition of rubber, as well as the certification of the product as ecologically friendly.

2 THEORETICAL REFERENCE

In order to explore the effects of proactivity and technological protection on environmental performance in civil construction companies, as well as to analyze the economic feasibility of investments to make the interlocked pavement product ecologically friendly, the concepts involved in this study are: environmental management in civil construction, technological protection and environmental performance, proactivity and environmental performance.

2.1 Environmental Management in Civil Construction

Environmental management is a global management system that addresses environmental concerns, through the allocation of resources, definition of responsibilities and continuous evaluation of practices, processes and procedures, aimed at developing, achieving, implementing, critically analyzing and maintaining the environmental policy established by the company - ISO 14001 and ISO 14004 (ABNT, 1996).

The contributions of environmental management can be segregated to the various activities of the organization, in which, in the productive sphere, this management can intervene in the control of respect for public regulations and implementation of environmental actions. In the sphere of innovation, through monitoring regulatory provisions and product evaluations related to environmental impacts and helping to define product and technology development projects. And in the strategic sphere, this management provides assessments of development potentials and emerging environmental constraints. (Corazza, 2002).

According to Barbieri (2004), environmental management is a guideline in administrative and operational activity with the objective of obtaining positive effects, either reducing or eliminating damages caused by human action to the environment. From an economic point of view, according to Donaire (2008), it has been observed that the costs associated with environmental variables are high, which can prove controversial, since it is possible to derive gains and generate business opportunities based on the green market (Rodrigues, 2010).

New criteria should be adopted for the selection of inputs, as well as alternative ways of dealing with waste resulting from construction works. The evolution of the sector in the adoption of environmental management systems as a means to reduce the impacts resulting from its productive activities and its products is essential.

2.2 Technological Protection and Environmental Performance

According to the resource-based view, it is particularly the combination of unique resources and the ability to exploit those resources that represent higher incomes (Barney, 1991; Amit & Schoemaker, 1993). According to Barney (1991), for a company's resource to become valuable, it must allow the company to explore opportunities or neutralize threats in the business environment. Technological protection refers to the existence of proprietary technologies and complex know-how (Zhao, Song, & Storm, 2013; Dickel, 2015).

Technologies can be protected by artificial and/or natural imitation barriers (Teece, 1986). In comparison with artificial protection by patents and copyright, natural barriers in terms of idiosyncratic, complex and ambiguous knowledge are considered particularly effective (Barney, 1991). This tacit knowledge is specific, historically developed and difficult to understand from outside and therefore difficult to invent (Dierickx & Cool, 1989). Enterprises with protected technologies have a favorable starting position (Shane & Stuart, 2002), because they can differentiate themselves from competitors more easily, imposing price expectations because of their exclusive offers and thus obtaining competitive advantages (Zhao *et al*., 2013).

Hart (1995) includes opportunities and barriers that arise from the natural environment from a resource-based perspective, the central argument of resource-based natural vision is that, because of increasingly scarce natural resources, companies that deal best with these constraints will succeed. Proprietary technologies transmit signals to customers, investors, and other stakeholders that affect their judgment on the predictability, honesty and reliability of a company (Batjargal & Liu, 2004; Santos, Teixeira, & Kniess, 2014).

Therefore, enterprises with protected technologies may find it less difficult to convince external partners of the ecological potential inherent in their technologies, and acquire external funding to finance and implement new environmentally friendly standards that, in turn, improve the environmental benefits that a company can offer (Dickel, 2017). Thus, by analyzing the theme, one has a hypothesis to be addressed in the study:

H1. In the presence of technological protection, there is environmental performance of the enterprise.

2.3 Proactivity and Environmental Performance

The combination of unique resources and the ability to exploit those resources that represent higher incomes, although resources are basically the inputs in production processes and services, organizational capabilities are the underlying processes in which resources are deployed and transformed to achieve the desired objective (Grant, 1991; Christmann, 2000; Dickel, 2017).

The strategic guidance of a company can be conceptualized as an organizational capacity that guides organizational practices and thus improves performance (Grant, 1991). The entrepreneurial guidance refers to the strategic posture of a company in terms of innovation, proactivity and propensity to assume risks (Miller, 1983; Covin & Slevin, 1989).

Proactivity denotes a behavior of searching for opportunities and future thinking that is characterized by anticipating market changes and acting ahead of competitors (Dickel, 2017). The proactive creation and identification of opportunities played an important role in many company concepts (Kreiser, Marino, Davis, Tang, & Lee, 2010; Tang, Tang, & Katz, 2013). The proactivity allows companies to identify and explore the opportunities arising from the business environment more quickly (Zahra & Covin, 1995). It also implies the ability to respond faster to unsatisfied customer needs, turning business opportunities into customer value. Proactivity also helps in forecasting future demand and thus transforming the evolution of market conditions into competitive advantages (Covin & Slevin, 1989; Menguc & Ozanne, 2005).

In addition, forward-looking behavior allows enterprises to address ecological challenges more effectively and comprehensively (Lumpkin, Moss, Gras, Kato, & Amezcua, 2013). Other benefits of proactivity derive from the implicit propensity to explore opportunities related to the environment, even in the presence of barriers (Dai, Maksimov, Gilbert, & Fernhaber, 2014). Thus, there is also a hypothesis to be addressed in the study:

H2. In the presence of proactivity, there is the environmental performance of the enterprise.

According to Dickel (2017), the exploitation of strategic assets is associated with a company's level of proactivity, a high proactive behavior promotes the identification of business opportunities, as well as benefits, that may result from protected technologies. On the contrary, companies with little proactivity can take advantage of protection market opportunities to a lesser extent than their competitors.

There are several arguments for a more effective exploitation of protected technologies due to their high proactivity. First, a high level of protection typically involves a higher level of uncertainty and complexity (Lynn, Morone, & Paulson, 1996; Zucker, Darby, & Armstrong, 2002).

Second, proactive companies can more quickly associate opportunities with the unique technological knowledge of an enterprise and exploit specific opportunities in a timely manner. Third, strong technological protection implies that enterprises have a greater reach in the pursuit of green innovations undisturbed by competitors (Eckhardt & Shane, 2003).

Finally, proactive behavior supports that enterprises are perceived as leaders in solving environmental challenges (Lumpkin *et al.*, 2013) which, in combination with strong technological

protection, increase the chance of obtaining support from external partners for their efforts (Dickel, 2017). Thus, the last hypothesis to be addressed in the study:

H3. The presence of proactivity affects the effect of technological protection on the environmental performance of the enterprise.

3 METHOD

This study is characterized, regarding the objectives, as descriptive since it aims at identifying, analyzing and interpreting characteristics of the analyzed population, employing statistical techniques and standardized data collection (Rodrigues, 2007). As for the research method, because there is interest in a specific case, the research is delimited and considered a single case study, and the choice is motivated by the possibility of analyzing an organization that provided a research opportunity on the theme (Stake, 1995). Regarding the approach to the problem, this study used primary data sources collected through structured questionnaires, starting from a defined population.

According to Yin (2001), the case study represents an empirical investigation and comprises a comprehensive method, with the logic of planning, data collection and analysis. The application of the study was developed in a civil construction company that produces and sells cement products, operating in the municipality of Cascavel in the state of Paraná. The company's object of study was founded in 1972, initially producing precast concrete parts.

In order to meet the proposed objectives, in the first stage, the Dickel model (2017) will be adopted, which explores the effects of proactivity and technological protection on environmental performance. In the second stage, in order to identify the volume of investments in the manufacture of ecologically friendly products, the Bertolini model (2009) was adopted, which analyzes the existence of economic viability to produce interlocking concrete paving blocks with the addition of rubber, as well as the certification of the product as being ecologically friendly.

3.1 Dickel Model

In the model a questionnaire is used with measurement scales in all variables, to the data are applied statistical techniques, which intends to analyze the associative relationship between a dependent variable in relation to the independent variables, being possible to evaluate the prediction of dependent variable values (Jaccard & Turrisi, 2003; Hair, Black, Babin, Anderson, & Tatham., 2009).

Contrary to what was suggested by Dickel (2017) in his study, hierarchical and logistic regression were not adopted, in this study we adopted the exploratory analysis, Spearman's correlation, together with the independence test. As these techniques are more adherent to the sample size. To apply the statistical techniques used in the study, the statistical software SPSS Statistics 22 from International Business Machines - IBM was used.

The variables adopted by Dickel (2017) correspond to the hypotheses formulated in order to confirm them and make up the theoretical framework in which the questionnaire used was formulated.

For the environmental performance variable, a scale based on KLD environmental strengths was used, which is considered a valid measure for environmental performance and that was applied in numerous studies (Walls, Berrone, & Phan, 2012; Tang & Tang, 2012; Delmas, Etzion, & Nairn-Birch, 2013). To increase the validity of the environmental performance measure, the existence of the environmental award variable was used as a second objective result indicator (Klassen & Mclaughlin, 1996).

The proactivity variable was taken from the business guidance scale developed by Miller (1983) and validated by Covin and Slevin (1989). Adapted by Menguc, Auh, and Ozanne, 2010, it

captures to what extent an enterprise demonstrates a behavior of searching for opportunities and future thinking. Technological protection was adopted by Zhao *et al*. (2013) and refers to the extent to which the technology of an enterprise can be protected by artificial imitation barriers, such as patents, and natural imitation barriers, such as complex, idiosyncratic and incorporated know-how.

Several inspection items have been included. Proactivity is typically measured as part of business guidance, the study also controlled two other key dimensions, innovation and propensity for taking advantage, as conceptualized by Miller (1983), Covin and Slevin (1989) and Menguc *et al*. (2010). Innovation describes the tendency of a company to encompass creativity and experimentation to develop and introduce new products, services or technological processes. A measure on risk taking captured the propensity of the company to commit significant resources to expensive projects with higher risks of failure and take bold actions under uncertainty.

The study was also controlled for environmental mission, which understood how the founders assess the relevance of environmental aspects against sales and profit targets (Hoff, 2012). A measure of stakeholder environmental influence was adopted by Darnall, Henriques, and Sadorsky. (2010) and consisted of capturing the extent to which customers, suppliers, employees, environmental groups, industries or business organizations, and investors can exercise power over a company's environmental activities. Finally, the age of the company was measured by the number of years since the enterprise was founded.

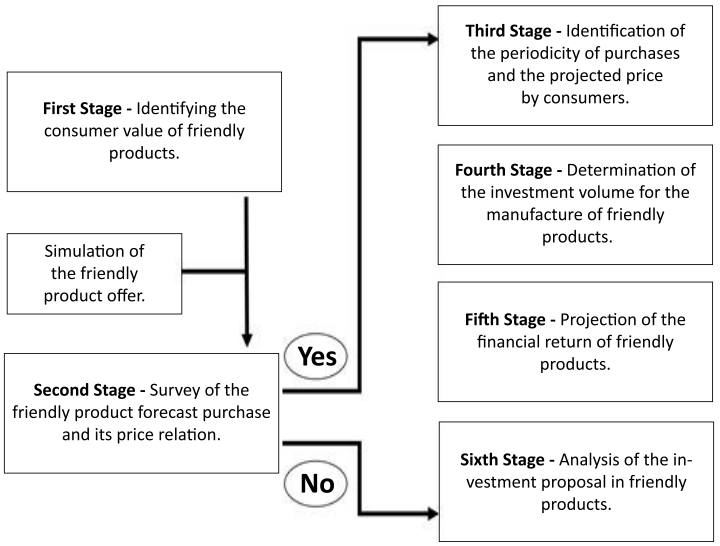
3.2 Bertolini model

The data were analyzed based on the investment analysis model for manufacturing ecologically friendly products created by Bertolini (2009). The company's object of study has as its main product the commercialization of interlocking concrete paving blocks, and its goals are customer satisfaction and the preservation of natural resources, which are indispensable for social welfare. Aiming to fulfill its mission and acquire an ecologically friendly differential in relation to its competitors, the company innovates in the production of interlocked pavements, seeking alternatives of raw materials as well as the reuse of waste.

Within this context, possibilities of changes to their main product have been raised. One is the replacement of some component of the traditional interlocked pavement for a more ecological alternative, not being verified in the market alternatives to the traditional product until now. In this regard, this research was proposed to study the financial feasibility of changing the composition of its main product: the interlocking concrete paving block. It was proposed the use of rubber residue - as verified in the existing literature, and proven technically feasible - in the proportion of 10% according to the study by Silva *et al*. (2017), replacing part of the fine aggregate (in this case sand) used as a raw material in the production of interlocking concrete paving blocks, seeking to meet Brazilian regulatory recommendations. Considering the initiative, having a product with new characteristics, the seeking for certification of the product as ecologically friendly was also proposed.

The model developed by Bertolini (2009) identifies the volume of investments necessary for the manufacture of ecological products, it is composed of six stages (Figure 1).

F igure 1 - Model development flowchart



Source: Bertolini (2009).

To project the value of the financial return, the equations in Box 1 should be used sequentially.

Box 1- Model Equation

Equation	Data
1. Projection of the unit valuation (P.V un.)	
P.P - (P.A + C.D) = P.V.un.	P.P. = Projected Price P.A. = Current Price of the organization C.D. = Direct Costs of the ecological product P.V.un. = Projection of the unit valuation
2. Projection of Periodic Total Valuation (P.V.T.p.)	
P.V.un. x Q.C.I. x N = P.V.T.p	P.V.un. = Projection of the unit valuation Q.C.I. = Quantity of Individual Consumption N = Number of consumers of the organization P.V.T.p. = Projection of the Periodic Total Valuation
3. Projection of the Discounted-Period Total Valuation (P.V.T.des.)	
P.V.T.p. x 1 - (1 + i) - n/i = P.V.T.des.	P.V.T.p. = Projection of the periodic Total Valuation n = project period i = rate of capital cost or the minimum required return P.V.T.des. = Projection of the discounted-period Total Valuation
4. Financial Return projected for each R$ invested (R.F.R$ in.)	
P.V.T.des./I.P.E. = R.F.R$ in	P.V.T.des. = Projection of the discounted-period Total Valuation I.P.E. = Investment to form the Ecological Product R.F.R$ in. = Financial Return projected for each R$ invested

Source: prepared by the authors based on the work of Bertolini (2009).

In the last stage of the model the analysis of the investment proposal in ecologically friendly products is performed. The result of the projected financial return equation (equation 4) is necessary to perform the analysis, from which the analysis of the proposal can be performed, according to the considerations below:

R.F.R$ in. < 1: there is no financial viability in the investment;
R.F.R$ in. = 1: there will be no projection of profit or loss;
R.F.R$ in. > 1: financial return is projected in the investment project.

3.2.1 Environmental Certification

In the civil construction sector there are several certification seals, but when it comes to raw materials, the seal of greater national expressiveness is the Falcão Bauer Institute [IFB], a Brazilian non-profit organization, one of the first certifiers of products in Brazil, which developed a certification model aimed at proving and ensuring the sustainability of products.

The certificate is voluntary, the process consists of documentary analysis, audit and a report with the actions. IFB performs an evaluation process of the corrective measures taken by the company, and if it is in accordance with the guidelines used, the applicant company receives the certification, which is valid for life, regulated by periodic maintenance audits and a recertification every three years (IFB, 2017).

3.3 Database

The questionnaire was applied to the company´s client portfolio under study, totaling 48 legal organizations, from which 20 represent the main source of the company´s revenue in the last 5 years, as indicated by the entrepreneur in an interview. These clients are characterized by large business ventures such as construction companies, construction material stores and business groups from other branches that have high demand for interlocking concrete paving blocks. The questionnaire was also applied to a second group, composed of potential clients, characterized by construction companies and construction material stores in Cascavel, composed of 135 legal organizations, this base was obtained from the Union of the Civil Construction Industry of Western Paraná [SINDUSCON] on September 18th, 2017, totaling a population of 183 organizations.

4 RESULTS

First, statistical techniques applied to the observations obtained with the use of the questionnaire extracted from the Dickel model (2017) were adopted in order to identify if there is a relationship among proactivity, technological protection and environmental performance. Subsequently, the Bertolini model (2009) was adopted, with the objective of analyzing the existence of economic viability to produce interlocking concrete paving blocks with the addition of rubber, and the certification of the product as ecologically friendly.

4.1. Dickel model

183 legal organizations were identified, characterized by construction companies and construction material stores located in the city of Cascavel, state of Paraná. From this total, 51 complete questionnaires were obtained (28% of the total).

First, the Likert scale was adjusted from seven points to five, in which the scales were replaced as follows: scale 3 to 2, 4 to 3, 5 and 6 to 4 and scale 7 to 5. This adjustment was necessary due to the low number of observations.

Subsequently, an exploratory data analysis was carried out, with the objective of examining the data previously, in order to identify relationships and assess the relevance of the questions in the questionnaire for each of the variables listed by Dickel (2017). It was observed that all the questions that make up the questionnaire were relevant in the construction of the variables; the commonalities were above 5 in all questions. It is possible to state that all the questions in the questionnaire were appropriate for the construction of the variables, i.e., the notes raised by the author, even being related to the public of clean technology companies, is also present in enterprises in the civil construction sector.

Table 1 shows the scales and averages found for each of the variables.

Table 1 - Average values of the variables

Variable	Scale	Average
Environmental strengths (KLD)	1-5	2.07
Environmental awards (PRE)	0-1	0.04
Proactivity (PRO)	1-5	3.10
Technological protection (TEC)	1-5	2.31
Innovation (INO)	1-5	2.80
Risk-taking propensity (RIS)	1-5	2.88
Interested party influence (INF)	1-5	3.22
Environmental mission (MIS)	1-5	2.24
Competitive intensity (INT)	1-5	4.05
Company age (IDE)	4-62	18

Source: prepared by the authors based on the research and use of the SPSS software.

Spearman's correlation, which consists of measuring the intensity and direction of the monotonic relationship between variables, was used to verify whether there is a relationship among the selected variables. The choice of this coefficient is justified by the use of scales in the questionnaire, this statistical technique is used when the data do not belong to a standard measurement scale, but where there is a clear order, from 1 to 5, for example.

Table 2- Spearman´s Correlation

Variables	KLD	TEC	PRO	INO	RIS	INF	INT	PRE	MIS	IDE
KLD	1.000									
TEC	**0.332***	1.000								
PRO	0.057	0.128	1.000							
INO	**0.285***	0.173	0.236	1.000						
RIS	**0.414****	**0.461****	0.031	**0.293***	1.000					
INF	0.160	0.086	**0.362****	-0.133	0.000	1.000				
INT	**0.326***	0.128	0.235	0.170	0.116	**0.395****	1.000			
PRE	-0.076	0.153	**0.292***	0.073	**0.284***	0.206	0.049	1.000		
MIS	0.164	0.026	-0.177	0.099	0.171	-0.161	-0.223	-0.053	1.000	
IDE	0.126	0.176	**0.308***	**0.280***	0.249	0.178	0.222	0.245	-0.199	1.000
Average	0.239	0.234	0.216	0.231	0.261	0.167	0.212	0.200	0.065	0.250
Standard Deviation	0.384	0.313	0.374	0.359	0.373	0.364	0.350	0.343	0.361	0.336

* Correlation is significant at level 0.05 (two-tailed).

** Correlation is significant at level 0.01 (two-tailed).

Source: prepared by the authors based on the research and use of the SPSS software.

After the correlation was performed in order to test the hypotheses raised, an independence test was performed. This is an asymptotic test that involves the detection of the existence of an association among the variables.

For hypothesis 1, the p value found is significant and greater than 0.05 (0.214 KLD environmental strengths; 0.895 environmental awards), that is, the null hypothesis is rejected, indicating that there is environmental performance in the presence of technological protection.

For hypothesis 2, the p value found is also significant and greater than 0.05 (0.257 environmental strengths KLD; 0.098 environmental awards), that is, the null hypothesis is rejected, indicating that there is environmental performance in the presence of proactivity.

On the other hand, for hypothesis 3, as in the others, the p value found is significant and greater than 0.05 (0.241), that is, the null hypothesis is rejected, indicating that the presence of proactivity affects the effect of technological protection on environmental performance.

4.2. Bertolini Model

In the first stage, the identification of value for consumers of the ecological product was carried out. Out of the 51 interviewees, 62.75% reported valuing products that had an environmental/ecological certification or seal at the time of purchase, and 37.25% reported not valuing.

Bertolini and Possamai (2005) state that environmental awareness is a determining factor for ecological behavior. According to the authors, it provides greater ease in identifying the best way to adapt consumption to the care taken with the environment.

In the second stage, the price and purchase forecasts were carried out. It is considered that the percentage of 62.75% of respondents who stated in the previous stage to value products that have a certification or environmental/ecological seals at the time of purchase, are possible consumers of the ecological interlocked pavement product, because they value such ecological characteristics, besides being consumers of the traditional interlocked pavement product.

From respondents, 56% said they were willing to pay up to 10% more for the product. Another 35% of respondents said they were willing to pay up to 20% more for the product, and 9% of respondents agreed to pay up to 50% more for the product, and none responded to options C (up to 30% more), D (up to 40% more), and F (over 51% more).

In the third stage, the amount of consumption was identified. Knowing that 56% would be willing to pay up to 10% more, the current price practiced by the organization (P.A.) was used, which is R$ 35.50 per m² + 10%, thus obtaining the price projection, which is (P.P.) = R$ 39.05 per m². It is worth mentioning that the use of the unit of measurement (m²) is due to the fact that the sale of interlocking concrete paving blocks by the company is carried out based on this unit of measurement.

In order to identify the periodicity of consumer consumption, aiming to reach the amount of individual consumption (IQ) of interlocked pavement products, the sum of the individual consumption/m²/year of the 62.75% interviewed who said they valued and are willing to pay more for the ecologically friendly product was counted.

The individual consumption value of the percentage of respondents who claim to value and are willing to pay more for the ecologically friendly product is 99,000 m²/year. At the end of this stage, it was discovered in the sample the consumers who value products that have an environmental/ecological certification or seals (stage 1), how much they are willing to pay extra for the ecologically friendly product (stage 2), the price projection (P.P.= R$ 39.05 m²), and the amount of individual consumption (Q.C.I.= 99,000 m²).

In the fourth stage, the investment volume was determined. With the objective of manufacturing interlocking concrete paving blocks with the addition of 10% rubber, there are two elements that must be altered and incorporated into the company's product, the alteration of the raw material for manufacturing and the search for certification of ecologically friendly products, Tables 3 and 4.

Table 3 - Quotation of the raw material to be added

Direct	Specifications	Company X	Supplier 1	Supplier 2	Average
Inputs	1 m³ of Rubber (equivalent to 600 kg)	R$ 690.00/m³ or 1.15/kg	Not found	Not found	R$ 690.00
Total					**R$ 690.00**

Source: prepared by the authors based on the research.

Since there will be no change in the production process of the new product, the only change will be the addition of 10% of rubber from useless tires to partially replace the average sand. After a price quotation survey, only one rubber supplier was found in the municipality, and the value sold is R$ 690.00/m³, or R$ 1.15/kg, this supplier was chosen for not incurring additional costs with transportation.

Table 4 - Quotation of the certification value

Indirect	Specification	The calculations are made based on time spent on the project plus associated costs that are only transferred to the operator (right to use the seal for a period of 36 months, certification and maintenance audits, travel expenses and inspector's stay). The amount of production that will be certified is also verified.			
Certification		Ecological Seal Falcão Bauer	Certifier 2	Certifier 2	Average - I.P.E.
Total		R$ 22,000.00	-	-	**R$ 22,000.00**

Source: prepared by the authors based on the research.

In addition to changing the raw material for production, there is the cost of certification, as shown in Table 4. According to the certifying company there are no fixed costs for the acquisition of certification, the total value includes certification audits and maintenance, fees, travel expenses and auditor´s stay to attest the product for obtaining voluntary certification of the product. Accredited by Inmetro and intended to demonstrate the ecological differential of the product, the certifying company and possession of the seal informed that there is an investment value, providing the right to use the seal for a period of 3 years, or 36 months.

To better elucidate this stage of the work, it is important to know the production process of the interlocked pavement product adopted by the company under study, seeking to make clear how the direct costs of the ecological product (C.D.) and the investment to form the ecological product (I.P.E.) were reached.

The production process of the interlocking concrete paving blocks begins with the selection and weighing of the materials, for the weighing of the raw material the quantity in kilos that the mixer can absorb (510 kg) is used as the basis. Table 5 shows the raw materials used, as well as the proportional cost per item and the quantity used in kilos, based on a mixer for the manufacture of the traditional interlocked pavement product.

Table 5 - Raw material, quantity and cost for the manufacture of traditional pavement

Item	Quantity in (kg) of a mixer	Proportional Value
Portland Cement CP-V ARI	100	R$ 64.00
Sand (average)	280	R$ 11.00
Gravel	130	R$ 5.00
Total	510	**R$ 80.00**

Source: prepared by the authors based on the research.

In order to obtain the proportional cost, the quotations informed by the company under study were considered: cement at R$ 25.60/40kg bag; sand at R$ 55.00/m³, with one m³ corresponding to 1,400 kg; gravel at R$ 50.00/m³, with one m³ corresponding to 1,300 kg.

Table 6 shows the raw materials used, the proportional cost per item and the quantity used in kilograms, based on a mixer for the manufacture of the traditional interlocked pavement product, in this case with the addition of rubber.

Table 6 - Raw material, quantity and cost for manufacturing the concrete paving blocks with added rubber

Item	Quantity in (kg) of a mixer	Proportional Value
Portland Cement CP-V ARI	100	R$ 64.00
Sand (average)	252	R$ 9.90
Gravel	130	R$ 5.00
Rubber 10 mm	12	R$ 13.80
Total	494	**R$ 92.70**

Source: prepared by the authors based on the research.

Analyzing tables 5 and 6, where the production costs of the traditional product and the one with the addition of rubber are shown, it was necessary to divide the total costs of the table by 4, taking into consideration that the quantity of raw material placed in a mixer produces 4 m² of interlocking concrete paving blocks. Thus, the direct costs (D.C.) totaled: R$ 28.40 per m² (cost 1, table 5) and R$ 31.57 per m² (cost 2, table 6). Then, the difference between the two costs was verified, that is, R$ 31.57

- 28.40 = R$ 3.17, which is the difference between the cost per m² for the manufacture of the interlocking concrete paving block with the addition of rubber in relation to that of the traditional pavement.

At the end of this stage, it was demonstrated that the additional costs in production are: direct costs, C.D.= R$ 3.17 and investments, I.P.E.= R$ 22,000.00. Totaling the volume of investments in the production and certification of the ecologically friendly interlocked paving products.

In the fifth stage, the projection of financial return was carried out. It is verified that considering the acceptable price by the consumers that affirmed to value and to be willing to pay more for the ecologically friendly product, there is a surplus of R$ 0.38 in relation to the price currently practiced, plus the direct costs.

In order to project the total periodic valuation (P.V.T.p) that the ecological product can provide to the company, 62.75% of those interviewed who stated they valued it and were willing to pay more for the ecologically friendly product were considered. Taking into account the population surveyed, a total of 183 consumer companies and potential customers of the company under study. Thus, it was established as a population that values ecological products 115 consumers, which correspond to the number of consumers of the organization (N).

Considering the value acceptable by the consumer, an amount higher than the adjustment costs, the total periodic valuation is R$ 4,326.30. For the calculation of the total projection of the discounted period (P.V.T. des.), 36 months (n) were used as the project period, which refers to the duration of the product certification. For the cost rate of capital or minimum required profitability, the equivalent Selic rate for the month, or i = 0.739% compatible for the business was adopted.

When the projected value is decapitalized, for a period of one year, at a rate of 0.739%, the total valuation of the period is positive in the amount of R$ 10,073.40. Based on the price that the consumer is willing to pay, for each Brazilian real invested in the environmental certification of the interlocked pavement product with the addition of rubber, a profit of R$ 4.58 is projected.

In the sixth and last stage, the analysis of the investment proposal in ecologically friendly products is carried out, that is, the feasibility analysis of the investment in the new product. Based on the scale of the return situation proposed by Bertolini (2009), it is inferred from the calculations made in the previous stages that there is financial viability for the investment, since the projected financial return for each real invested was R.F.R$ in.>1, which indicates financial return on the investment project.

5 DISCUSSION

Independence tests point to the existence of an association between technological protection and environmental performance, as well as proactivity and environmental performance and also between proactivity and technological protection.

The results of this study meet the work of Batjargal and Liu (2004), the authors state that in the presence of technological protection, to have environmental performance is expected, since proprietary technologies transmit signals to customers, investors, and other interested parties that affect their judgment on the predictability, honesty and reliability of a company.

These results are reaffirmed by Zhao *et al*. (2013) and Shane and Stuart (2002) when they see that enterprises with protected technologies have a favorable starting position, because they can differentiate themselves from competitors more easily, impose price expectations because of their exclusive offers and thus obtain competitive advantages that bring positive influences, affecting their environmental performance.

Similarly, the results of this study corroborate with Barney (1991), the author states that for a company resource to become valuable, it must allow the company to explore opportunities or neutralize threats in the environment of a company.

With regard to environmental performance in the presence of proactivity, this study found results similar to the work of Zahra and Covin (1995), the authors show in their studies the relationship of proactivity with environmental performance, by stating that proactivity allows companies to identify and explore more quickly the opportunities arising from the business environment.

The results obtained also reaffirm those found by authors such as Lumpkin *et al*. (2013), Dean and McMullen, (2007), when pointing out that proactive enterprises are more likely to find and explore promising ecological business opportunities. The environmental analysis represents one of the starting points for beginning strategic planning. Performing a systematic environmental scanning makes companies have greater perception of ecological opportunities and have a deeper view of the creation of social value (Kreiser *et al*., 2010).

This study found similar results to the studies presented by Dickel (2017) and Menguc and Ozanne (2005), with respect to environmental performance, the authors state that proactive enterprises are more likely to find and explore promising ecological business chances, proactivity denotes a behavior of seeking opportunities and future thinking that is characterized by anticipating market changes and acting ahead of competitors.

Tang *et al*. (2013) state that there is little evidence on the specific role of proactivity in environmental performance, although proactivity is a fundamental aspect in business guidance due to its relationship with the environmental performance of the enterprise. The statements of the authors ensure the results evidenced in this research.

The results of this study point out that the presence of proactivity affects the effect of technological protection on environmental performance, in the same way, Covin and Slevin (1989) point out that proactivity implies the ability to respond more quickly to the unsatisfied needs of customers, transforming business opportunities into customer value. Proactivity also helps in forecasting future demand and thus transforming the evolution of market conditions into competitive advantages.

The results of this study are based on the study of Eckhardt and Shane (2003), who relate proactivity and technological protection, the authors state that to translate the ecological opportunities arising from protected technologies, a proactive behavior in terms of scanning the business environment to identify complementary knowledge and environmental trends is necessary.

With the environmental concern as background, many companies are integrating the environmental theme in their processes and products, thus demonstrating the need to verify if this environmental proactivity will also help to improve the financial performance of companies. Sen *et al.* (2015), in a study involving companies in the manufacturing industry in India and the United Kingdom, pointed out a positive correlation between environmental proactivity and financial performance.

Considering the need for continuity of companies from the profit and return on invested capital, economic viability is a determining factor in business, as well as sustainability based on the practices of 'Social Responsibility' of organizations has become an important aspect in maintaining business in the contemporary scenario (Mcwilliams & Siegel, 2001; Carvalho, Cirani, & Ribeiro, 2015).

Thus, through the Bertolini model (2009), it was possible to analyze the existence of economic feasibility to produce interlocking concrete paving blocks with the addition of rubber and certification of the product as ecologically friendly.

According to Carvalho *et al*. (2015), it is not so simple to develop sustainable business, because it requires the review of processes, products and strategies. These changes may generate insecurity for managers, because they fear losing profitability, increasing costs or deviating from their core business.

6 FINAL CONSIDERATIONS

Within the objective proposed by this study, considering the perception of the consumers interviewed, it is confirmed that there is an association between technological protection and proactivity in environmental performance, which may assume an important potential impact on growth, profitability or survival of the company under study. The results are in line with the work of Dickel (2017).

The offer of the interlocked pavement product with the addition of rubber and ecological certification is financially viable for the company under study. Investments in new raw materials and the acquisition of an environmental certification seeking ecological characteristics would be able to bring positive financial returns for this interlocked pavement industry.

There is a latent need for eco-efficient materials that show technical and financial viability for their use in the civil construction sector, because in this industry there is an agent of great impact on the environment, due to the large use of natural resources and also the large number of waste generated. On the other hand, the sector shows high potential for absorption and proper disposal of the waste generated.

Whether due to market pressure or increasingly conscious consumer pressure, companies should seek to build a differentiated corporate image with stakeholders and be "environmentally responsible". Considering this view, it is believed that the organization can obtain competitive advantage by adopting a proactive stance in favor of the environment.

One of the limitations of the study is based on the use of the Dickel model, since it was not possible to infer the magnitude of the relationship among the variables, only to test whether there is an association between them or not. Another is in data collection, limiting the analysis to 51 observations in a population of 183 companies. Although there are limitations in the study, the analysis of the sample provides important information about the variables: proactivity, technological protection and environmental performance.

As suggestions for future researches, we recommend applying this research in other industries focused on products from the use of natural raw materials that are renewable or non-renewable, but that they can be reused, recycled or which cause the minimum impact during their manufacturing process and after use. Applying the research using statistical techniques such as regression to measure the magnitude of the relationship among the variables.

Therefore, the main contribution of this study is the analysis of the economic feasibility regarding the manufacture of interlocked pavement products with ecological certification.

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AUTHORS

1. Adriana Ireno de Souza

Graduated in Economic Sciences at the State University of Western Paraná (UNIOESTE) and Professional Master's in Business Administration at the State University of Western Paraná (UNIOESTE).

E-mail: adrianaireno@gmail.com

ORCID: https://orcid.org/0000-0002-0506-712X

2. Leonardo Alves de Oliveira Casimiro

Graduated in Agronomy at the Dom Bosco Catholic University (UCDB) and Professional Master's degree in Business Administration at the State University of Western Paraná (UNIOESTE).

E-mail: leonardocasimiro2@gmail.com

ORCID: https://orcid.org/0000-0002-8332-3002

3. Emanuel Campigotto Sandri

PhD student in Business Administration at the Federal University of Paraná, Research Line in Innovation and Technology. Master´s degree in Business Administration at the State University of Western Paraná (UNIOESTE). Post-graduated in Business Management at Getulio Vargas Foundation. Held a Business Administration degree at Assis Gurgacz Foundation.

E-mail: emanuel.sandri@hotmail.com

ORCID: https://orcid.org/0000-0002-4539-2090

4. Jerry Adriani Johann

PhD in Agricultural Engineering – UNICAMP - SP / Dr Engenharia Agrícola - área de concentração em Desenvolvimento Rural Sustentável – UNICAMP – SP. Professor Associado at Universidade Estadual do Oeste do Paraná (UNIOESTE).

E-mail: jerry.johann@hotmail.com

ORCID: https://orcid.org/0000-0001-6184-8011

5. Geysler Rogis Flor Bertolini

PhD in Production Engineering – UFSC - SC / Dr Engenharia de Produção - UFSC – SC. Professor at Universidade Estadual do Oeste do Paraná (UNIOESTE).

E-mail: geysler_rogis@yahoo.com.br

ORCID: http://orcid.org/0000-0001-9424-4089

Contribution of authors.

Contribution	[Author 1]	[Author 2]	[Author 3]	[Author 4]	[Author 5]
1. Definition of research problem	√	√	√	√	√
2. Development of hypotheses or research questions (empirical studies)	√	√		√	
3. Development of theoretical propositions (theoretical work)			√		√
4. Theoretical foundation / Literature review	√	√	√		√
5. Definition of methodological procedures	√	√	√	√	
6. Data collection		√	√		√
7. Statistical analysis	√	√		√	
8. Analysis and interpretation of data	√	√	√	√	
9. Critical revision of the manuscript				√	
10. Manuscript writing	√	√	√		√
11. Other (please specify)					