

Article

Environmental Innovation and Sustainability in Small Handicraft Businesses in Mexico

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Abstract: In this study, the relationship between environmental innovation and sustainability is analyzed in 168 handicraft businesses in the Mexican states of Oaxaca, Puebla, and Tlaxcala. The results show a direct, positive relationship between environmental innovation and sustainability in three dimensions: economic, social, and environmental. In terms of determination, the variables that best explain sustainability are: organization type, product innovation, and process innovation. The age of the handicraft businesses was not a significant factor in explaining sustainability. This study concludes that handicraft businesses make sustainable choices more as a result of a desire for profit maximization than as a result of environmental consciousness, as can be explained by neoclassical view of economics.

Keywords: environmental innovation; sustainability; handicraft businesses

1. Introduction

In the last decade, shareholders and stakeholders have increased pressure on companies to broaden their accountability beyond solely economic performance to include environmental performance and sustainability. Business sustainability entails the adoption of objectives for sustainable development,

namely social equity, economic efficiency, and environmental performance. In order to achieve this multitude of targets, fundamental changes are necessary; these changes are denoted as innovation [1].

The majority of environmental concerns in existence today revolve around large organizations, as they have traditionally been perceived as those mainly responsible for environmental degradation. This is especially true for multinational corporations operating in specific industrial sectors such as chemicals, petrochemicals, and cement, among others [2]. A large percentage of existing research focuses exclusively on large firms and their role in achieving sustainability through innovative solutions [2-4].

The role of small and medium-sized enterprises (SMEs) has frequently been ignored, and although Biondi and Iraldo ([2], p. 613), mention that interest in SMEs and their impact on environmental deterioration began to emerge in the 1990s, in Mexico, this situation has not changed. Furthermore, this problem is generalized, as there is a lack of empirical research dealing with the real problematic of innovation and sustainability on the level of enterprises, whether large, medium, or small.

The amount of pollution that a small enterprise generates cannot be compared with that of large organizations; nevertheless, as Hillary [5], mentions, small enterprises pollute in a collective manner. Considering the fact that they are numerous and by their nature heterogeneous, as well as their limited capacity to deal with the many issues that confront them on a daily basis, the priority of SMEs will always be to address those concerns seen as having a more immediate bearing on their survival: namely competitiveness, the skills and training of staff, productivity, interest rates, *etc.* As a result, sustainability may not be viewed as a main priority, causing these businesses to continue utilizing processes which, collectively, contribute significantly to pollution.

SMEs represent more than 90% of the total number of enterprises operating in Mexico and constitute a fundamental element in the economic development of the country, generating 52% of the GDP and making up 72% of formal employment [6]. Handicraft businesses are vital to the Mexican economy as they represent the main source of income for many families. This type of business plays a central role in the economy of many regions, as they attract both national and international tourism [7]. Handicraft businesses are traditional in nature and depend on the entrepreneurial abilities of their owners. The majority employ rudimentary production processes, and have a low production volume; their sales are primarily confined to local and national markets. This type of firm has traditionally been forgotten in the discussion of environmental administration; this is unfortunate, especially considering how these businesses base their production on the use of natural resources, and, in many cases, employ highly polluting processes. Under these circumstances, it has become increasingly urgent for this kind of business to play its part in finding reliable ways of managing environmental problems through innovative means [8]. The present study is especially relevant as the business practices of handicraft firms have devastated entire species of natural resources, including copal wood, used as a prime material in handicraft production, and oak wood, used for firing pottery handicrafts. This study also seeks to provide empirical evidence of the effects of environmental innovation on the sustainability of pottery businesses.

Today, many SMEs are already stepping up to the challenges of environmental innovation; there is increasing empirical evidence of small and micro enterprises in developing countries undertaking environmental innovation processes, spurred by the potential benefits and advantages that such innovation can offer [5].

In order to gain a better understanding of the relationship between innovation and sustainability, and the role that small handicraft businesses play in that relationship, the following questions need to be addressed:

- What is the nature of the relationship between innovation and sustainability in small handicraft businesses?
- What are the barriers or obstacles that small handicraft businesses face when developing the environmental innovations that allow them to achieve sustainability?
- What are the advantages or benefits that handicraft business can expect if they pursue environmental innovations?

The present paper is organized in the following manner: the next section is a review of the uses of the term innovation, considering its relationship to sustainable development and addressing the pertinent literature on evolutionary and neo-classical theories of innovation; this is followed by the methodology used in this study and its results. Finally, conclusions and recommendations for future research are drawn.

2. Literature Review

2.1. Innovation Oriented toward Sustainable Development

According to Rennings [4] and Blum-Kusteres and Hussain [3], business changes in the direction of sustainability are termed environmental innovation, or eco-innovation. Environmental innovations go beyond technological change; they include organizational changes, as well as changes in any stage of economic activity, from the design of a product or service to its marketing strategy [9]. Environmental innovation is motivated by concern for the direction and nature of progress. Thus, innovations oriented toward sustainability have the additional attribute of reducing environmental burdens in at least one area, and thus contributing to improving the state of the natural environment.

Environmental innovations develop new ideas, behaviors, products, and processes; the application of these new elements contributes to a reduction in environmental burdens in general, or to specific ecological sustainability targets. Environmental innovations may be developed by firms or by non-profit organizations; they may or may not be traded on markets, and their nature may be technological, organizational, social, or institutional [4,10].

Environmental technology comprises two aspects: the correction of environmental damage (e.g., decontamination of soil) and the prevention of further damage to the natural environment. Integrated environmental technology can be subdivided into product- and process-integrated measures [11]. While Rennings ([4], p. 323) suggests that organizational changes are the result of administrative instruments on the enterprise level, such as eco-audits, the authors of this paper hold that the relationships established with other enterprises, clients, providers, NGOs, and governmental organisms responsible for environmental issues can also increase the importance of such innovation. Changes in lifestyles and consumer behavior are often defined as social innovations. Duchin [12] argues that the idea of social innovation is new, and in order to explain it in environmental terms, especially when referring to environmental policy, it is necessary to understand not only technology but also lifestyle dynamics.

Klemmer, Lehr and Löbbe [10], mention a fourth nature of innovation, related to the institutional aspect. Innovative institutional responses to problems of sustainability may range from local networks and agencies (e.g., regarding water resources of local relevance) to new regimes of global governance (e.g., an institution responsible for global climate and biodiversity issues) and international trade [13]. The Intergovernmental Panel on Climate Change (IPCC) is an example of an innovative scientific network on the global level; numerous other institutions have been established on national, regional, and local levels to allow public discourse regarding environmental and technological impact assessment. Thus, institutional innovations are often seen as the basic foundation for a policy of sustainability [14].

The present study addresses innovations in terms of technological changes in products or processes (which are closely linked with profit gain in handicraft businesses), as well as organizational changes (related to the improvement of the business, though they do not necessarily imply a maximization of profits). Social and institutional changes have barely begun to be addressed in the context of handicraft businesses and the conceptualization and interpretation of these changes, especially in the case of Mexico, is still vague.

2.2. The Evolutionary and Neo-Classical Economic Views of Innovation

In the literature, it is common to find the relationship between innovation and sustainability explained from two perspectives: neo-classical theory and evolutionary theory. Neo-classical theory has examined environmental innovation in two aspects: environmental economics and economic innovation [4].

Environmental economics seeks to maximize ecological and social wellbeing through an efficient assignation of resources. The superiority of market-based instruments such as taxes and tradable permits has long been the basic lesson of environmental economics in terms of innovation. These mechanisms have been identified as the environmental policy instruments with the highest dynamic efficiency (innovational efficiency) [15,16]. The advantage they offer is that they provide permanent incentives for further, cost-efficient emission reductions. However, the contribution of environmental economics to environmental innovation suffers from a simple, mechanistic stimulus-response model of regulation, and neglects the complexity of the determinants that influence innovational decisions in firms [4]. In environmental economics, innovation is seen first as a means for achieving profit maximization, and only then as a mechanism for achieving ecological and social wellbeing, as motivated by the obligation of compliance with regulations through fines or permits.

The central issue in economic innovation, in contrast, has been whether technological innovation has been driven by technological development (technology push) or by demand factors (market pull). This discussion has revolved around the structure of regulation (push/pull effect), which, together with environmental policy, has a strong impact on environmental innovation. As the factors of technology push and market pull alone do not seem to be enough, environmental innovations require specific regulatory support [4]. Cleff and Rennings [17] analyzed the different factors that influence eco-innovation decisions in firms; they found that, in terms of their innovation goals, eco-innovative firms attach a significantly higher level of importance to the goals of cost reduction and total quality management (TQM). From this perspective, environmental product innovation is significantly driven

by the strategic market behavior of firms (market pull effect), while environmental process innovation is driven more by regulation (regulatory push/pull effect). “Soft” and voluntary environmental policy measures may be sufficient for pioneers; nevertheless, “hard” measures (command and control instruments, duties, *etc.*) seem to remain necessary for the diffusion of integrated changes to non-innovative firms [4]. Innovation economics has led to insights into the complexity of factors influencing innovation decisions, and has bettered our understanding in terms of the decisions of firms interested in incremental changes over the short term.

According to Rennings [4], while neoclassical models accurately analyze marginal or incremental changes induced by different kinds of incentives, they are of limited value in the analysis of more radical changes in technological systems, as well as in organizational and societal contexts. According to Freeman [14], incremental innovations can be characterized as continuous improvements of existing technological systems (*i.e.*, they fit in existing input-output tables); for Blum-Kusterer and Hussain [3] these changes may arise from an exogenous shock to the system, e.g., when a cost-reducing innovation becomes available. Radical innovations, in contrast, are discontinuous (*i.e.*, they require new lines and columns in input-output tables). Blum-Kusterer and Hussain ([3], p. 302) refer to changes that originate within the system as endogenous changes; these allow for proactive, and not only reactive, behavior.

Evolutionary theory, therefore, was developed to open up the “black box” of radical changes, to examine their components: unpredictable interactions of sub-systems, irreversibility, path-dependency, lock-in effects of technological trajectories or bifurcation. Evolutionary approaches are more interested in the analysis of transition and learning processes than in equilibrium states, and assume bounded rationality and rules of thumb rather than optimization [4].

In contrast to the emphasis in neo-classical economics on profit-maximizing behavior on the part of the firm, evolutionary economics emphasizes process and change. It views the behavior of a firm at any given time as “governed by its current decision rules, which link its actions to various environmental stimuli” ([18], p. 91). While in orthodox neo-classical economics, decision rules are assumed to be the consequence of maximization, in evolutionary theory they are treated as simply reflecting the historically determined routines (regular and predictable patterns of behavior) that govern the actions of a firm [19].

To summarize, neo-classical economics characterizes a firm’s behavior in terms of sustainable development as an “equi-marginal principal of maximization” ([20], p. 47), where firms make sustainable choices if and only if they satisfy what is assumed to be their objective: maximizing the profits of the firm. In contrast, evolutionary economics depicts corporate behavior as a learning process, wherein outcomes are defined not by absolute efficiency but by historical precedents, thus implying the need to investigate innovation.

2.3. The Context of Handicraft Businesses

Studies of handicraft businesses have shown that success is the result of innovation, *i.e.*, changes derived from the creativity of the artisans. Thus, when artisanal product characteristics, the abilities of the business, and the possibility of generating competitive strategies are insufficient for the market, product innovation is what tends to determine profit increase [21-23]. Nevertheless, in Mexico, only

5% of the total number of artisans innovate and are successful at this activity; 65% continue to utilize rudimentary systems and live off their craft, and the remaining 30% fall in between [24].

The low percentage of innovative handicraft businesses may be due to the slow nature of the process of innovation development, and a lack of strategies for innovation. The development of new products is founded on what the owners of the firm believe will sell, or in accordance with seasonal considerations. Thus, in the absence of structure and the sufficient bases for innovation in the artisanal sector, innovation is either produced out of necessity, or not produced at all.

Hernandez, Yescas and Dominguez [25] argue that when innovation in the artisanal product is slow and long term, it occurs in a continuous manner. Due to the nature of knowledge transmission from one generation to the other, artisans are culturally disinclined towards innovation. Organizational innovation attempts to establish order and reduce uncertainty in terms of the behavior of personnel. Intervening factors include the power of communication, the organization type, and the relationships the firm has with clients or providers. Process innovation is still limited, as it depends to a great degree on the customs and beliefs of the artisans, where cultural conservation aspects stand out. According to Hernandez, Yescas and Domínguez [25], artisans give a greater level of importance to product innovation than to organizational or process innovation, as in many cases organizational and process innovation require new knowledge that is difficult for artisans to acquire.

The majority of pottery businesses employ innovations in their products as these innovations are easier to implement; moreover, they imply less cost, time, and knowledge, as was argued by Hernández, Yescas and Domínguez [25]. This type of innovation in the pottery sector is related to the size, shape, and design of the product, as well as the type of materials used in its production. Innovations related to the production process imply not only changes in the type of technology used, but also in the methods or manner of creating handicraft pieces. In terms of technology, artisans may implement innovations in the equipment, tools, and utensils used during the production process. These innovations are related to others such as replacing wood-burning kilns with gas kilns, acquiring mills for grinding and mixing minerals, and replacing electric pottery wheels with manual pottery wheels, among others. The majority of these changes tend to be related to external technologies that artisans adopt, although there are some artisans who also adapt existing technology (mills and pottery wheels) to their requirements. Though these artisans are not numerous, they do exist; they are innovators in a more pronounced sense than those who adopt existing technology. Regarding production methods, many artisans do change their production methods, including the painting and glazing of pieces, with the aim of increasing production and decreasing costs. In cases such as this, these artisans can be considered innovators as they implement new manners of making their pieces (e.g., serial painting of pieces, instead of painting one piece at a time, glazing pieces in lots using submersion techniques instead of one by one). The majority of artisans are innovators and adapt technology only when doing so implies replacing sophisticated equipment such as kilns, mills, and pottery wheels [24,26].

Interest in environmental innovation on the part of handicraft businesses is a relatively recent phenomenon, and has begun to be more evident as a result of negative publicity directed at handicraft businesses that work with clay, due to the presence of toxic substances (lead) in these products. This has considerably affected the sales of these businesses, and consequently, their profitability [27]. Exposure to lead and consequent lead poisoning is a serious problem for public health. During pottery production, when pieces are glazed, there is a risk of lead exposure both for those who apply the glaze

and for those who live near the kilns. Moreover, artisanal activity is based on the use of natural materials, many of which are in danger of extinction, such as live oaks, palms, and copal; deforestation is a serious problem surrounding many communities. This situation makes it necessary to critically examine the effects of artisanal activity on the environment.

With the aim of increasing sales, many handicraft businesses attempt to make good use of the prime materials that they employ. The clay that is obtained from cutting recently shaped pieces is reused in the creation of other pieces; the water used in the production process is reused as much as possible; to avoid contamination of materials in the production process, gas kilns are implemented that allow artisans to fire their pottery in a shorter amount of time than that required by wood-burning kilns or kilns that burn raw petroleum and gasoline, and given the design characteristics of these ovens, a greater number of pieces can be processed at once. This type of innovation is acquired by pottery businesses from external technology providers, as the equipment that such changes entail is sophisticated, and difficult for artisans to fabricate or modify. In general, this type of kiln is easily found in large businesses with sufficient economic resources for the purchase of this type of technology. To a lesser extent, there are artisans that modify their equipment, including kilns, mixers, and pottery wheels with the aim of increasing their production levels and becoming more competitive. These artisans draft their own designs for equipment or machinery, and support their design with the advice of experts such as electricians, mechanics, metalworkers, *etc.* Production process changes are made, lead-free enamels replace enamels with lead; green tags are implemented; and relationships are established with other handicraft businesses in order to form NGOs such as “Barro sin Plomo” (Lead-Free Clay), which seeks the clean certification of handicrafts.

2.4. Age of the Business and Organization Type

Two important aspects can be observed, in terms of context, which explain the relationship between environmental innovation and sustainability in handicraft businesses: the organization type, and the age of the business. Seroa da Motta [28] and Henri and Journeault [29] argue that the larger the enterprise, the more likely it is to adopt a greater number of procedures for environmental control. Stanwick and Stanwick [30] suggest that larger firms receive a high level of attention from the general public, which may in turn “encourage” firms to have a higher level of social sustainability.

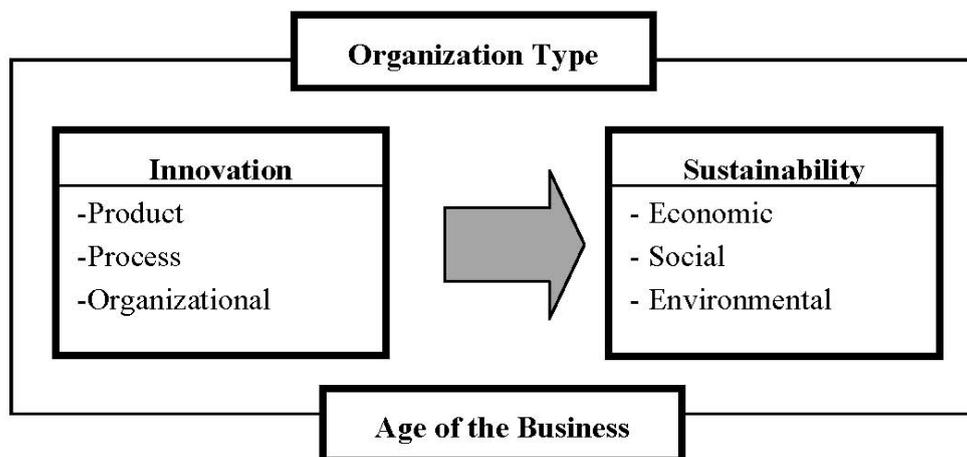
In the artisanal context, large firms give greater importance to environmental behavior, as they have the investment capacity required to carry out actions benefitting the environment. Small firms, on the other hand, may find investing in environmental aspects too risky, as their resources are more limited [8]. In addition, large firms have a greater level of reputation and recognition, which may benefit them in terms of social sustainability.

According to Hernandez, Dominguez, Moreno and Ortega [31] and Hernandez, Dominguez and Ramos [21], the age of handicraft businesses is related to competitiveness; the more years the firm has been operating in the market, the more sales it brings in, in comparison with recently created businesses. Moreover, older, more established businesses may show a greater interest in social and environmental aspects as a result of the experience they have acquired through the years and the prestige that characterizes them; both of these factors may be determinant in adopting pro-environmental and pro-societal measures. The majority of pottery businesses use rudimentary procedures; as a result, their

pollution levels due to obsolete technology are limited. As Hillary [5] mentions, small enterprises, as a function of their technology, do not contaminate as much as large enterprises.

Based on these considerations, the following research model is proposed (see Figure 1), in which it is supposed that innovation (in products, processes, and organizational aspects) affects sustainability (economic, social, and environmental) in handicraft businesses. This relationship is conditioned on two characteristics of these firms: organization type and age of the business.

Figure 1. Proposed Research Model for Handicraft Businesses.



3. Methodology

This section introduces the methodological approach adopted for empirical analysis, in order to test the research model and address the research questions posed earlier in this document. The following sections describe in detail: (i) the sample and subjects of this research; and (ii) the variables and measures used.

3.1. Sample and Subjects

The sample was selected in an arbitrary manner, following qualitative criteria for the selection of states with the greatest representation of pottery handicraft businesses, viable logistics, and accessible costs, with the aim of being representative in terms of the type and age of the organization. Thus, the sample was structured in the following manner: small businesses, 66.7%; large businesses, 33.3%; businesses with an age ranging from 1 to 15 years, 42.3%; 16 to 35 years, 35.1%; 36 to 55 years, 15.5%; 56 or more years, 7.1%. Accordingly, a sample of 168 utilizable questionnaires was obtained, as is shown in Table 1.

Table 1. Sample Distribution by State.

State	Frequency	Percentage
Oaxaca	84	50,0
Puebla	44	26,2
Tlaxcala	40	23,8
Total	168	100,0

The subjects of this study were pottery businesses in three states of the Mexican Republic: Oaxaca, Puebla, and Tlaxcala. The present study focuses on this business type, as the real impact of pottery activity on the natural environment is unknown, especially in areas where there has been a large amount of deforestation caused by the use of wood in firing handicrafts. Moreover, this activity utilizes natural resources in its production process, as well as toxic substances such as lead in the glaze of the final product. Studying this type of organization in the context of developing countries such as Mexico offers the unique opportunity of finding wider variations in environmental performance than would be found in developed countries. In order to improve environmental performance among handicraft businesses without negatively affecting economic performance, it is necessary to achieve sustainability in this sector.

3.2. Variables and Measures

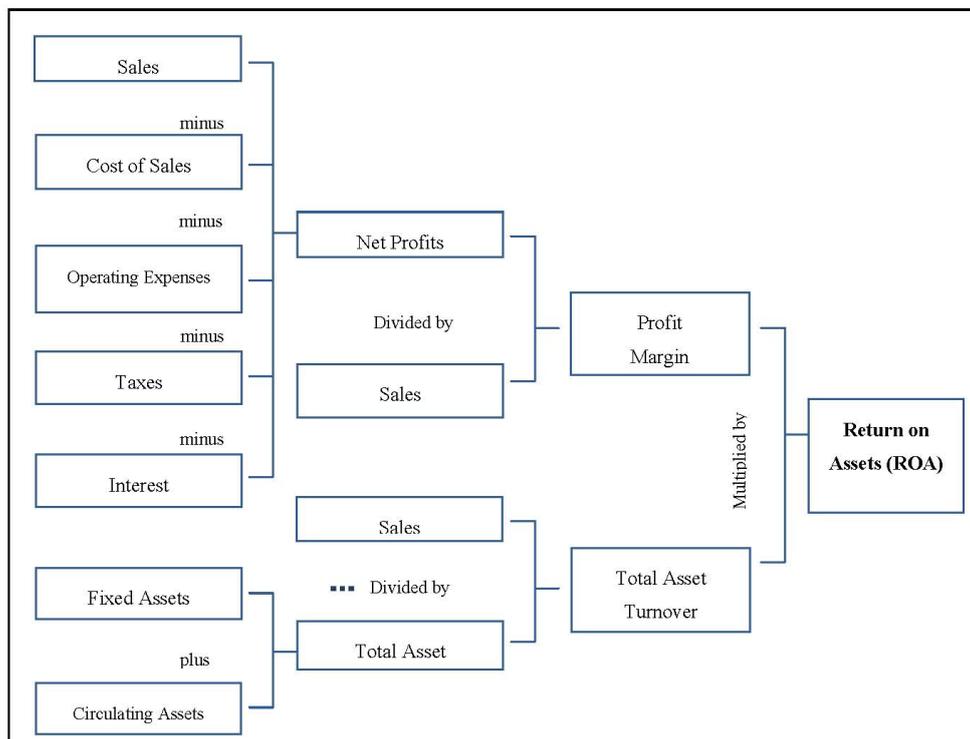
3.2.1. Dependent Variable

The dependent variable utilized in this study was sustainability, in its three dimensions: economic, environmental, and social.

Economic sustainability refers to the profitability of handicraft businesses. In order to measure this variable, the DuPont Method was used (see Figure 2), which allowed for the analysis of profitability in terms of financial indices. The profitability index considered here was return on assets (ROA), which indicates the efficiency with which firms utilize their asset base. The following formula was used to calculate ROA:

$$ROA = \text{Asset Turnover} * \text{Profit Margin} = [\text{Sales} \div \text{Assets}] * [\text{Profits} \div \text{Sales}]$$

Figure 2. Structure of the DuPont Method.



Environmental sustainability refers to the ecological result of preserving, protecting, and caring for the environment. The empirical measure of environmental sustainability includes the evaluation, on the part of the firm, of the reduction of its environmental impact in a number of dimensions, listed in the first column of Table 2. For each item on the questionnaire, the degree to which the business had reduced its negative environmental impact over the period of one year was reported. Interviewees were asked to respond on a Likert five-point scale, from 1 (no reduction) to 5 (strong reduction), as developed by Wagner and Schaltegger [32]. Higher point values correspond to greater reduction.

Table 2. Factor analysis of the environmental sustainability.

Reduction of Environmental Impact	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
1. Kiln Fuel						
Live oak logs	.856	.070	.049	.288	.022	.146
Pine (ocote) logs	.860	.230	.024	.224	−.047	.095
Another type of log	.886	.175	.185	.088	.007	.098
Industrially produced wood	.871	.179	.166	.108	.055	.093
Wood waste products (sawdust)	.866	.205	.203	.154	.002	.087
Charcoal	.755	.209	.069	.189	.171	.275
Plastic	.852	.108	.120	−.067	−.057	−.117
Paper, cardboard, newspaper, cans, milk containers, old clothes and rags	.882	.128	.139	−.033	−.074	−.086
Leaves, branches, rinds, fruit seeds, bones, animal parts, and food waste	.901	.121	.089	.144	−.056	−.008
2. Non-Renewable Resources						
Kaolin	.393	.680	.114	.194	.072	.086
Feldspar	.411	.540	.185	.221	−.016	.258
Silica sand	.030	.856	.183	.000	.085	.107
Cobalt oxide	.035	.915	.099	.017	.007	.073
Copper	.153	.896	.075	.072	−.032	.105
Antimony oxide	.180	.897	.125	.103	.016	.063
Hematin	.276	.826	.182	.213	−.016	.019
Manganese oxide	.361	.718	.179	.318	−.009	.079
Graphite	.396	.669	.101	.301	−.007	.078
3. Water						
Use of water in the production process	.030	.103	.892	.176	.225	.103
Use of water to clean tools and workspaces	.093	.090	.892	.207	.190	.074
Use of water for personal hygiene of personnel after a work shift	.138	.115	.909	.152	.173	−.073
Use of water in toilets and sinks	.092	.249	.670	.238	−.074	−.071
Water consumed exclusively in the business	.239	.192	.868	.216	.153	.064
Water consumed in the home	.373	.244	.749	.191	.188	−.054
4. Risk of Severe Accidents						
Use of protection and safety equipment	.086	.172	.201	.878	.084	.097
Availability of first aid supplies	.366	.256	.212	.763	.042	.132
Training in First Aid	.256	.155	.245	.825	.027	.066
Training in industrial hygiene and safety	.005	.038	.240	.882	.088	.077
Training in the appropriate handling of toxic substances	.271	.275	.261	.759	.087	.058
5. Energy						
Energy consumed exclusively in the business	−.047	−.018	.360	.070	.853	.016
Energy consumed in the home	.007	.061	.327	.165	.876	.015
6. Air Pollution						
Reduction in air emissions	.363	.156	.083	.319	−.076	.729
Reduction in the number of firings of the pieces	−.081	.302	−.046	.083	.082	.798
% of Variance	42.91	13.62	10.61	6.96	3.89	3.33
Total Variance Explained						81.32
Cronbach's Alfa						.95

Rotation method: varimax with Kaiser normalization. The rotation has converged on six iterations. Extraction method: principal component analysis.

Social sustainability measures the performance of the business in relation to its impact on other interested parties (communities, employees, providers, *etc.*). This includes such topics of business ethics as: participative decision making, community commitment, honesty, and corruption. In order to

measure this variable, 11 questions were designed based on the handicraft business context. On the five-point Likert scale, business owners were asked to report to what degree they agreed or disagreed with the statements shown in the first column of Table 3.

Environmental sustainability, social sustainability and innovation were validated internally with common factor analysis incorporating a varimax rotation, Kaiser normalization, and reliability analysis with Cronbach's alpha. The factor analysis results are summarized in Tables 2-4. The goal of factor analysis was to validate the internal consistency of each variable, determined as items with loadings ≥ 0.5 . The sum of the validated items in factors was used to measure each of the variables (environmental sustainability, social sustainability and innovation) as a single construct. The reliability coefficients (Cronbach's alpha) of each of the variables are shown at the bottom of Tables 2-4. The reliability range was from .88 to .95, which has been classified by several researchers as excellent [33].

Environmental sustainability loaded on six factors: fuels (factor 1), non-renewable resources (factor 2), water (factor 3), risk of severe accidents (factor 4), energy (factor 5), and air pollution (factor 6), as can be seen in Table 2.

Table 3. Factor analysis of social sustainability.

To what degree do you agree with the following statements?	Factor 1	Factor 2	Factor 3
1. Honesty			
It is my responsibility to encourage the personnel of my business to adopt environmental conservation practices	.699	.145	.012
I have adopted environmental conservation practices	.815	.313	.260
I participate in activities that take care of the environment	.818	.256	.244
I am interested in the conservation of the environment	.845	.228	.017
I am aware of the environmental problems that exist in my community	.739	.285	.087
2. Business Ethics			
I am aware of the environmental problems that my handicraft business creates	.248	.884	.143
I am aware of the activities in my handicraft business that increase pollution or harm the environment	.280	.900	.167
I am aware of the fact that artisanal activity makes excessive use of some natural materials	.226	.884	.159
I am aware of the fact that the use of toxic substances is harmful to the environment and to human health	.349	.801	.160
3. Community Commitment			
It is my responsibility to encourage other handicraft businesses to adopt environmental conservation practices	.002	.157	.920
I have encouraged other handicraft businesses to adopt environmental conservation practices	.298	.221	.837
% of Variance	53.67	13.69	11.47
Total Variance Explained			78.83
Cronbach's Alfa			.90

Rotation method: varimax with Kaiser normalization. The rotation has converged on five iterations. Extraction method: principal component analysis.

Social sustainability also loaded on three factors: honesty (factor 1), business ethics (factor 2) and community commitment (factor 3) (see Table 3).

3.2.2. Independent Variable

Innovation is conceptualized as all change carried out in handicraft businesses that tend to prevent or reverse the damage caused to the environment. Business owners were asked about changes aimed at protecting the natural environment carried out in their businesses over the period of one year. A

five-point Likert scale was used, ranging from 1 (none) to 5 (very many), where 1 (none) means zero changes, 2 (very few) denotes that the handicraft business carried out one or two changes, 3 (some) signifies from three to four changes, 4 (many) indicates from five to six changes, and 5 (very many) indicates more than six changes (see Table 4).

Table 4. Factor analysis of environmental innovation.

Changes Made In:	Factor 1	Factor 2	Factor 3
1. Products			
Minerals used in the production of paints	.883	.208	.046
Minerals used in the production of glazes	.864	.236	.052
Minerals used in the production of enamels	.840	−.115	.209
Use of dangerous or toxic substances	.763	−.216	.373
Use of chemicals	.769	.134	−.092
2. Processes			
Pottery production method	.207	.828	.151
Pottery painting method	.417	.637	.317
Pottery glazing method	.481	.672	.302
Tools	−.219	.765	.322
Utensils	−.053	.767	.215
3. Organizational Method			
Other handicraft businesses	.063	.437	.755
Clients	.108	.331	.886
Providers	.164	.236	.893
% of variance	43.71	22.77	9.73
Total variance explained			76.22
Cronbach's Alfa			.88

Rotation method: varimax with Kaiser normalization. The rotation has converged on seven iterations. Extraction method: principal component analysis.

Factor analysis revealed that the scales used to measure innovation loaded on three factors: products (factor 1), processes (factor 2) and organizational method (factor 3). The sum of all these factors was used to measure innovation as a single construct (see Table 4).

3.2.3. Context Variables

Organizational type: organizational type was classified using two groups, according to the similarity of characteristics of each type of artisanal production. As based on Novelo [34], small businesses are those with the characteristics of family workshops, but which also display certain characteristics of small capitalistic workshops, and can be characterized as: the owner continues to participate in the production process; a lack of a total decoupling of family ties from business decisions; and in some cases, the lack of a space exclusively dedicated to the workshop or to the exhibition of handicrafts. Large businesses, in contrast, are those with manufacturing characteristics, but which still retain certain characteristics of small capitalist workshops, and can be characterized as: the production of sumptuary and decorative objects; a greater purchasing power which is reflected in a

better standard of living; the contracting of personnel; and a space reserved for the workshop and the exhibition of finished pieces.

Age of the business: this variable was measured according to the number of years for which the handicraft business had been in operation at the time of the interview.

4. Results and Discussion

To determine whether a relationship exists between environmental innovation and sustainability in handicraft businesses, a correlation analysis was performed between the two variables. The results showed that environmental innovation has a direct, positive relationship with sustainability (.453, $P \leq 0.01$). This relationship is maintained in its three dimensions: economic (.340, $P \leq 0.01$), social (.283, $P \leq 0.01$) and environmental (.468, $P \leq 0.01$) (see Table 5). According to interviewees, environmental innovation in their businesses oriented towards the substitution of non-toxic substances for toxic substances, the replacement of wood-burning kilns with gas kilns, work in conjunction with NGOs such as Barro Sin Plomo (Lead-Free Clay), and pressure on the part of clients to produce handicrafts that are less harmful to human health not only improved their sales in the long run, but has made them socially and environmentally more responsible, raising awareness of the activities they carry out and the success that they can achieve through strategies aimed at sustainability.

Table 5. Bivariate correlation between innovation and sustainability.

	μ	<i>SD</i>	<i>Sustainability</i>	<i>Dimensions of Sustainability</i>		
				<i>Economic</i>	<i>Social</i>	<i>Environmenta l</i>
Environmental innovation	2.96	1.00	.453 **	.340 **	.283 **	.468 **
Product innovation	1.98	.773	.613 **	.332 **	.465 **	.573 **
Process innovation	1.95	.716	.394 **	.242 **	.225 **	.434 **
Organizational innovation	2.01	.765	.254 **	.266 **	.107	.299 **

** Correlation is significant at levels equal to or less than 0.01 Escala Likert from (1) to (5).

In the context of the pottery handicraft businesses, product innovation was found to be the most significant factor for businesses sustainability (.613, $P \leq 0.01$), followed by process innovation (.394, $P \leq 0.01$), and finally organizational innovation (.254, $P \leq 0.01$). The relationship between product innovation and economic sustainability is given with the same level of significance (.332, $P \leq 0.01$), as well as its relationship with social sustainability (.465, $P \leq 0.01$), and environmental sustainability (.573, $P \leq 0.01$). Process innovation was most significantly related to the environmental sustainability of the business (.434, $P \leq 0.01$), followed by its economic sustainability (.242, $P \leq 0.01$), and, finally, social sustainability (.225, $P \leq 0.01$). Of the three dimensions of environmental innovation, organizational innovation was the least significantly related to the sustainability of these businesses. This dimension was only significant in relation to the environmental sustainability (.299, $P \leq 0.01$) and social sustainability of pottery businesses. These results indicate that the sustainability of said

businesses is primarily given by changes in products and processes, which have been few. Nevertheless, despite the fact that the interviewed business indicated that they had implemented more changes on the organizational and administrative level, these changes are not greatly related to sustainability. As was mentioned above, sustainability was found to be related only to economic and environmental results, and not to social ones.

To test for the intervention of context variables, such as type and age of the organization in the relationship between environmental innovation and sustainability, these variables were controlled, as can be seen in Table 6. The relationship between environmental innovation and economic and environmental sustainability was maintained even when organization type and age were controlled for. Social sustainability, in contrast, was found to be less significant after controlling for organization type. Thus, the interest on the part of handicraft businesses in carrying out environmental innovations or being sustainable is not a function of how large or small the business is, or the years that it has been in business. Rather, the concern on the part of these businesses regarding environmental aspects is related to their desire to grow and satisfy the demands of new markets. In terms of social aspects, the relationship between environmental innovation and sustainability begins to be moderated by organization type, as well as by larger size, and greater social responsibility on the part of the handicraft business.

Table 6. Partial correlation controlling for context variables.

<i>Independent Variable</i>		<i>Sustainability</i>	<i>Dimensions of Sustainability</i>		
			<i>Economic</i>	<i>Social</i>	<i>Environmental</i>
Environmental innovation	Zero order				
	Controlling for:	.453 **	.340 **	.283 **	.468 **
	Organization type	.391 **	.287 **	.227 *	.408 **
	Age of the organization	.451 **	.325 **	.280 **	.468 **
* Correlation is significant at levels equal to or less than 0.05 ** Correlation is significant at levels equal to or less than 0.01.					

Table 7 displays the results of regression analysis; Model 1 refers to the total sustainability variable in its three dimensions (economic, social, and environmental). Organization type, product innovation, and process innovation are important in determining this variable. For Model 2, economic sustainability, organization type, product innovation, and organizational innovation are useful. Social sustainability (Model 3) is determined solely by product innovation, and environmental sustainability (Model 4) is determined by organization type, product innovation, and process innovation.

The age of the organization was not an important factor in explaining any of the models of sustainability in handicraft businesses. This differs from results found in the literature, where the age of the business was clearly shown to be an important variable in determining the environmental and social behavior of firms [21,31]. The contrasting results found in the present study are due to the fact that the majority of the businesses interviewed in this document were, at the time of the study, in the age range of 1–15 years (42.3% of the total sample). This type of business is just beginning its

artisanal activity, when compared with those that have been in business for more than 56 years (7.1%) Nevertheless, organization type is manifest in total sustainability, economic sustainability, and environmental sustainability. It does not seem to be important in explaining social sustainability; this differs from the results found by Stanwick and Stanwick [30], who reported that large enterprises present higher levels of social sustainability than small enterprises.

Table 7. Regression Analysis, Sustainability of Handicraft Businesses.

	<i>Sustainability</i>	<i>Dimensions of Sustainability</i>		
		<i>Economic</i>	<i>Social</i>	<i>Environmental</i>
Constant	3.058 **	-.055	1.735 **	.518 *
Organization type	.195 *	.153 *		.150 *
Age of the organization				
Product innovation	.507 **	.237 *	.465 **	.445 **
Process innovation	.153 *			.219 **
Organizational innovation		.163 *		
R	.655	.401	.465	.635
R²	.429	.161	.217	.403
Standard error	1.443	.139	.913	.860
F Value	41.11	10.49	45.89	36.84
Significance	.000	.000	.000	.000

* Correlation is significant at levels equal to or less than 0.05; ** Correlation is significant at levels equal to or less than 0.01.

5. Conclusions

The environmental problematic being faced today on a global level has led to a greater interest in environmental issues, with the aim of finding solutions to the damage that has already been incurred. On the micro level, much interest has arisen in analyzing the environmental impact that large enterprises generate; little attention has been given to the environmental impact generated by small enterprises, which collectively generate high levels of pollution [5]. This is particularly true in developing countries, where environmental topics have only recently begun to be addressed, and great uncertainty exists as to the efficiency of environmental administration.

In small pottery businesses, environmental innovation determined sustainability. Of the three dimensions of environmental innovation, product innovation best explained sustainability in its three dimensions (economic, social, and environmental). Process innovation only contributed to explaining the environmental sustainability of these businesses. Changes carried out on the level of production processes consisted of adopting sophisticated technologies, and incorporating them into traditional pottery production processes. This type of change also includes modifying handicraft production methods. Organizational innovation contributed to explaining the economic sustainability of the business. Changes made at the administrative level oriented towards commercialization and establishing contacts with providers, clients, and other handicraft businesses were found to be important in increasing sales. Contextual variables such as the age of the business and organization type did not significantly impact the environmental innovation–sustainability relationship, and although organization type slightly modified the level of significance, it was not enough to sever the

relationship between environmental innovation and sustainability. This indicates that the contextual variables did not have an impact on the sustainability of these businesses through product, process, or organizational innovation. Therefore, environmental innovation in and of itself is an important factor that allows artisanal businesses not only to increase their profits, but to be socially and environmentally sustainable as well.

This study analyses the relationship between environmental innovation and sustainability in handicraft businesses, as supported by the evolutionary and neo-classical views of innovation. The results were found to be more consistent with the neo-classical view than the evolutionary view, as the interest on the part of artisans in implementing changes that benefit the environment and society is related to a desire to achieve greater participation in the market and, most recently, an interest in complying with certain environmental standards in order to be able to sell their products on both national and international markets [21,22].

In terms of innovation types, product innovation was found to best explain sustainability and its dimensions. This is supported by the findings of Hernandez, Yescas y Domínguez [25], who argued that artisans give greater importance to product innovation than to process or organizational innovation. Thus, in the context of handicraft businesses, artisans carry out changes in the design, size, materials and/or components used in the production of their crafts, and limit improvements oriented towards processes or organizational methods, as these improvements imply the investment of a greater amount of financial resources (*i.e.*, in the acquisition of new machinery, equipment, and tools). Further obstacles faced by handicraft businesses in developing environmental innovations and achieving sustainability are:

- Artisans' lack of awareness of the dangers of using toxic substances or chemicals in handicraft production;
- Artisans' lack of awareness of the impact of irrational use of natural resources in the production of handicrafts;
- The scarcity of the economic resources needed to acquire and/or modify the equipment and machinery used in the production process;
- Artisans' limited contact with providers and clients, which in many cases restricts the generation of innovative ideas.

Pottery businesses could take advantage of environmental innovations in order to position green products in international markets; however, this has been limited by pollution problems on the part of some of these businesses. In terms of social sustainability, the more pottery businesses implement environmental innovations, the better use they will give to natural resources. This will allow them to attain social and environmental legitimacy, which may translate into economic benefits.

Thus, it is important to understand that sustainability in the handicraft sector is not limited to the responsible use of resources, but rather seeks a constant market capable of strengthening its traditions, techniques, and uses, in addition to seeking responsible innovation to satisfy the demands of both national and international markets.

Future research could be directed towards establishing sustainable forms of resource management for artisanal use. This would guarantee not only the permanence of the populations of species utilized in the creation of handicrafts, but also constitute an incentive to conserve and protect important natural

areas. It would also constitute a mechanism for assuring the continuity and transmission of local knowledge regarding the use and management of these species and the manufacturing of artisanal pieces. Furthermore, it would contribute, in both rural and urban populations, to encouraging a more conscious consumption of products whose production pollutes less than that of their industrial counterparts.

Further research could also investigate the variables or factors that determine environmental innovation in artisanal businesses.

References

1. Elzen, B.; Geels, F.W.; Green, K. Theoretical explorations of transitions. In *System Innovation and the Transition to Sustainability: Theory, Evidence and Policy*; Elzen, B., Geels, F.W., Green, K., Eds.; Edward Elgar Publishing Limited: Northampton, MA, USA, 2004; pp. 19-76.
2. Biondi, V.; Iraldo, F. Achieving sustainability through environmental innovation: The role of SMEs. *Int. J. Technol. Manag.* **2002**, *24*, 612-626.
3. Blum-Kusterer, M.; Hussain, S. Innovation and corporate sustainability: An investigation into the process of change in the pharmaceuticals industry. *Bus. Strategy Environ.* **2001**, *10*, 300-316.
4. Rennings, K. Redefining innovation—eco-innovation research and the contribution from ecological economics. *Ecol. Econ.* **2000**, *32*, 319-332.
5. Hillary, R. *Small and Medium-Sized Enterprises and the Environment: Business Imperatives*; Greenleaf Publishing Limited: Sheffield, UK, 2000; p. 378.
6. Secretaria de Economía, PyME, 2003. Available online: <http://www.economia.gob.mx> (accessed on 14 February 2011).
7. Toledo, A.; Hernández, J.P.; Griffin, D. Incentives and the growth of Oaxacan subsistence businesses. *J. Bus. Res.* **2010**, *63*, 630-638.
8. Sánchez, P.S.; Domínguez, M.L; Hernández, J.P. Género y comportamiento ambiental de los negocios de artesanías de barro. *Gestión y Política Pública* **2010**, *XIX*, 79-110.
9. Dosi, G. The Nature of the Innovative Process. In *Technical Change and Economic Theory*; Dosi, G., Freeman, C., Nelson, R., Silverberg, G., Soete, L., Eds.; Pinter Publisher Ltd: London, UK and New York, NY, USA, 1988; pp. 221-238.
10. Klemmer, P.; Lehr, U.; Löbbe, K. *Environmental Innovation: Incentives and Barriers (Innovation Effects of Environmental Policy Instrument)*; Analytica Verlag: Berlin, Germany 1999; p. 139.
11. Hemmelskamp, J. Environmental policy instruments and their effects on innovation. *Eur. Plann. Stud.* **1997**, *5*, 177-194.
12. Duchin, F. Reducing Pressures on the Environment: Forward-Looking Solutions and the Role of Formal Models. In *Innovation-Oriented Environmental Regulation: Theoretical Approaches and Empirical Analysis*; Hemmelskamp, J., Rennings, K., Leone, F., Eds.; Physica-Verlag: New York, NY, USA, 2000; p. 347.
13. Rennings, K.; Koschel, H.; Brockmann K.L.; Kühn, I. A regulatory framework for a policy of sustainability-lessons from the neoliberal school. *Ecol. Econ.* **1999**, *28*, 197-212.
14. Freeman, C. *The Economics of Hope: Essays on Technical Change, Economic Growth and the Environment*; Pinter Publishers: New York, NY, USA, 1992; p. 243.

15. Downing, P.B.; While, L.J. Innovation in pollution control. *J. Environ. Econ. Manag.* **1986**, *13*, 18-29.
16. Milliman, S.R.; Prince, R. Firm incentives to promote technological change in pollution control. *J. Environ. Econ. Manag.* **1989**, *17*, 247-265.
17. Cleff, T.; Rennings, K. Determinants of Environmental Innovation – Empirical Evidence from the Mannheim Innovation Panel and an Additional Telephone Survey. In *Innovation-Oriented Environmental Regulation: Theoretical Approaches and Empirical Analysis*; Hemmelskamp, J., Rennings, K., Leone, F., Eds.; Physica-Verlag: New York, NY, USA, 2000; pp. 300-302.
18. Nelson, R.R.; Winter, S.G.; Schuette, H.R. Technical change in an evolutionary model. *Q. J. Econ.* **1976**, *90*, 90-118.
19. Nelson, R.R.; Winter, S.G. *An Evolutionary Theory of Economic Change*; Harvard University Press: Cambridge, MA, USA, 1982; p. 437.
20. Daly, H.E.; Cobb J.B. Cobb, C.W. *For the Common Good: Redirecting the Economy toward Community, the Environment, and a Sustainable Future*; Beacon Press: Boston, MA, USA, 1989; p. 482.
21. Hernández, J.P.; Domínguez, M.L.; Ramos, A.O. Canales de distribución y competitividad en artesanías. *Espiral* **2002**, *9*, 143-164.
22. Domínguez, M.L.; Hernández, J.P.; Toledo, A. Competitividad y ambiente en sectores fragmentados. El caso de la artesanía en México. *Cuadernos de Administración* **2004**, *12*, 127-158.
23. Domínguez, M.L.; Hernández, J.P.; Gúzman, D. Orientación estratégica y desempeño en un proceso de desarrollo de productos: Alfarería en Santa María Atzompa, Oaxaca, México. *Contad. Adm.* **2008**, *225*, 79-101.
24. Jiménez, J.C; Domínguez, M.L.; Martínez, C.J. Estrategias de competitividad de los negocios de artesanía en México. *Pensamiento y Gestión* **2009**, *26*, 165-190.
25. Hernández, J.P.; Yescas, M.; Domínguez, M.L. Factores de éxito en los negocios de artesanía en México. *Estudios Gerenciales* **2007**, *23*, 77-99.
26. Hernández, J.P.; Domínguez, M.L.; Caballero, M. Factores de innovación en negocios de artesanías en México. *Gestión y Política Pública* **2007**, *XVI*, 353-379.
27. Jiménez, A. Impedir que la artesanía se vuelva maquila, reto de México en el mercado global: FONART. La Jornada, 2001, Available online: <http://www.jornada.unam.mx> (accessed on January 2002).
28. Da Motta, RS. Analyzing the environmental performance of the Brazilian industrial sector. *Ecol. Econ.* **2006**, *57*, 269-281.
29. Henri, J.F.; Journeault, M. Environmental performance indicators: An empirical study of Canadian manufacturing firms. *J. Environ. Manag.* **2008**, *87*, 165-176.
30. Stanwick, P.A.; Stanwick, S. The relationship between corporate social performance, and organizational size, financial performance, and environmental performance: An empirical examination. *J. Bus. Ethics* **1998**, *17*, 195-204.
31. Hernández, J.P.; Domínguez, M.L.; Moreno, I.; Ortega, N. Estrategias competitivas en artesanía. *Iztapalapa* **1998**, *18*, 261-276.

32. Wagner, M.; Schaltegger, S. The effect of corporate environmental strategy choice and environmental performance on competitiveness and economic performance: An empirical study of EU manufacturing. *Eur. Manag. J.* **2004**, *22*, 557-572.
33. Srinivasan, A. Alternative measure of system effectiveness: Associations and implications. *MIS Q.* **1985**, *9*, 243-253.
34. Novelo, V. *Artesanías y Capitalismo en México*; SEP-INAH: Puebla, Mexico, 1976; p. 270.

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