Cleaner Production in Small Firms taking part in Mexico´s Sustainable Supplier Program

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Abstract

This research assesses the environmental and economic benefits and costs of cleaner production projects formulated by small- and medium-sized enterprises (SMEs) participating in a sustainable supply program in Mexico. The program was designed as a public-private voluntary partnership to spur cleaner production dissemination in SMEs that are part of global supply chains. The study analyzes how project benefits varied as a function of different types of cleaner production applications, company characteristics and participant profiles.

The results, based on statistical evidence from 1,934 cleaner production projects formulated by a group of 972 small and medium sized firms, indicate that on average waste recycling and waste prevention projects yielded higher economic and environmental value than energy efficiency and water conservation projects. Waste reduction applications also showed more attractive net present values than technology innovations or best practices. Economic and environmental benefits of cleaner production are positively related to firm size. This study contributes to the literature by providing empirical evidence on how larger supplier and waste recycling projects influence potential positive outcomes of cleaner production applications in a program such as the Mexican sustainable supply program. More broadly, it provides evidence on the potential costs and benefits of sustainable supply efforts.

Keywords: Sustainable supply, cleaner production, Small- and medium-sized enterprises

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1. Introduction

Small and medium sized enterprises (SMEs) are considered cornerstones of sustainable development (Blackman, 2006). As they represent about ninety-nine percent of all enterprises, they are an important source of employment generation in many countries (Newberry, 2006). Likewise, they are identified as an important source of environmental contamination. Hillary (2000) estimates that SMEs are responsible for about 30% of all environmental load discharged by industry due to their outdated technology and limited capacity to implement environmentally friendly innovations. Moreover SMEs often appear invisible to environmental agencies, especially in emerging economies where the institutional capacity of environmental agencies is limited (Blackman, 2006). These conditions make dissemination of environmental improvements among SMEs challenging.

Cleaner production (CP) has been identified as a prevention-oriented strategy useful to reduce the environmental load associated with the processes and products of SMEs (Baas, 2006). Efforts to promote CP applications in SMEs have been put forward in Latin America (Leal, 2006) and throughout the world (Baas, 2006). Initiatives have involved technical assistance programs offered by external consultants or cleaner production centers (Grutter & Egler, 2004), voluntary agreements (Jimenez, 2007; Blackman *et al.*, 2009; Blackman *et al.*, 2010), financial support for investments in clean technology (Blackman, 2000), and information dissemination through sectoral guides and CP manuals (Ehrenfeld *et al*., 2002).

Success of these programs in terms of environmental improvements of SMEs has been limited, as few companies adopt CP practices after their participation in these types of programs (Fernández-Viñé *et al.,* 2010; Blackman *et al*., 2010; Parker *et al.*, 2009; Stone, 2006a; Baas, 2006). In addition, the scope of these programs was limited, reaching out to only a small proportion of this large group of firms (Blackman, 2006; 23). Accordingly, improving the environmental performance of Latin American SMEs remains challenging, as noted by Vives, Corral and Isusi (2005). Their study of some 1,300 SMEs in five Latin American countries showed that only about 30 percent of the firms in the sample undertook environmental protection practices.[1]

A number of constraints in disseminating CP concepts among SMEs have been identified: Vives (2006:39) cites "lack of resources, lack of knowledge, and the perception that they cause no environmental impact". Other studies showed a lack of vision and knowledge on the part of business managers (Baas, 2006; Studer *et al.,* 2005; Hilson, 2002); lack of internal resources such as investment capital (Mitchell, 2005; Hitchens *et al.,* 2003; Frijns & Van Vliet, 1999); limited technical know-how and information about viable cleaner practices and technologies (Van Berkel, 2006; Grutter & Egler, 2004; Hilson, 2000); little staff motivation for development and implementation of CP alternatives (Stone, 2006b; Baas, 2006); and lack of availability of tailor-made tools and strategies for environmental improvement in SMEs (Jenkins, 2004).

[1] Vives, Corral and Isusi (2005) did not specify whether or not any of the firms they studied had participated in any CP-related dissemination programs

These arguments explain the barriers to CP implementation in terms of capacities needed by firms, such as information availability, technical capabilities, and financial resources. Other reported barriers highlight motivational constraints of managers, such as lack of management interest, lack of market drivers, and lack of regulatory enforcement. These arguments do not give insights into company-specific characteristics influencing CP, nor do they provide understanding of the organizational features influencing the costs and benefits of CP applications (Dieleman, 2007; Vickers & Cordey-Hayes, 1999). To date, the influence of company characteristics such as size and industry sector on the benefits of CP in supply chain initiatives remains largely unknown.

Further complicating matters, CP is a broad concept that involves a range of different applications and benefits. The academic literature (Van Berkel, 2006; Dobes & De Palma, 2010) and CP manuals and guides (CPTS, 2005; CNPML&TA, 2009; CNPLH, 2009) distinguish different typologies of CP applications. Nevertheless, little is known about the comparability of these different typologies, because most academic research has studied the costs and benefits of particular applications or programs (Hong Nath, 2007; Nazer, 2006; Hedge *et al.*, 2000).

This study assessed the costs and benefits of cleaner production projects designed by small firms that participated in a sustainable supply program in Mexico. The program was designed as a public-private partnership to disseminate cleaner production among a significant group of SMEs throughout the country. Its database of 1,934 CP projects, the vast majority of which were designed by SMEs, provided an unusually rich and consistently measured empirical base for statistical research. The cumulative costs and benefits of the program, as a whole, make a case for dissemination of CP among SMEs in emerging economies such as Mexico.

Two main research questions guided this study. First, what were the economic and environmental costs and benefits of CP applications designed in a large-scale sustainable supply program targeted at SMEs? Second, what company and project characteristics influenced program outcomes? By answering these questions, this study contributes to the literature by providing empirical evidence on how firm and project characteristics influence potential outcomes of CP applications. In addition, it provides new evidence on the potential economic and environmental benefits of sustainable supply efforts.

The remainder of this paper is organized as follows. Section 2 presents a review of the literature and offers a simple conceptual framework for program analysis. Section 3 describes the Mexican Sustainable Supply Program (MSSP), since it is essential to understand the context in which the analyzed CP experiences were developed. Section 4 details the research methodology and describes the data sources used. Section 5 presents an assessment of the financial and environmental benefits of the CP projects designed within the MSSP. Section 6 relates research results to the relevant literature and discusses implications of the findings for CP dissemination. Section 7 presents conclusions and recommendations for additional research.

2. Framework for cleaner production and its applications

This section briefly reviews the literature on cleaner production, its diverse typologies of applications, and the different mechanisms that have been identified for CP promotion among SMEs. In so doing, it also sets the stage for the framework of analysis used in this research.

➢ Cleaner production

Cleaner Production (CP) is an environmental management concept that surged in the 1970s as a strategy for environmental improvement that is complementary to environmental regulation (WBCSD - UNEP, 1998). It advocates a voluntary approach for reducing environmental waste while also reducing costs. An early paper on the subject defines cleaner production as (Baas *et al.*, 1990): "…the continuous application of integrated, preventive environmental strategy to both processes and products to reduce risks to humans and the environment." The concept assumes that contamination is a result of the "ineffective" use of raw materials, products or byproducts.

The Natural Resource Based View (NRBV) of the firm introduced by Hart (1995) can be used as a theoretical perspective to understand the rationale behind the CP concept and other voluntary sustainability-related business strategies. The NRBV perspective considers scarce, valuable and non-substitutable resources, and the capabilities to manage them, as key pillars of competitive advantage. From this perspective, CP is seen as a strategic capability for minimizing emissions, effluents and waste through continuous improvement. Firms that adopt CP or related strategies will evidence simultaneous reductions in emissions and in capital expenditures for end-of-pipe pollution control. Over time, a CP strategy will move from being an exclusively internal (competitive) process to an external (legitimacy-based) activity as a pillar of the competitive advantage of the firm (Hart, 1995). In the NRBV of the firm, the positive balance between benefits and costs should trigger firms´ self-interest and lead them to adopt CP measures voluntarily.

Two closely related concepts are eco-efficiency (Schmidheiny, 1992) and pollution prevention (Erkman, 1997). These also assume environmental contamination is a result of the "ineffective" use of raw materials, products or byproducts. All of these concepts emphasize *prevention-oriented* alternatives that aim at improvement in design, production, delivery, use, and final management of products, services and processes.

➢ Typologies of CP Applications

Cleaner production encompasses a broad range of applications such as changes in manufacturing technologies and practices, changes in chemicals and other raw material inputs, and even changes in products and packaging (Hirschhorn, 1997). Different typologies have been put forward in the literature to classify CP applications. Following the resource-based view of the firm

(Wernerfelt, 1984), early publications emphasized reduced resource usage in industrial processes, such as energy efficiency, efficient water use, waste reduction, and recycling (Van Berkel, 1994; Baas, 1998; 1995;). This typology uses the environmental benefits of applications as the main classification criterion of CP projects.

Later classifications take into account the level of innovation involved (Montalvo-Corral, 2002). The idea behind this typology is that CP innovations imply an organizational change process, where management and key staff people must learn to handle new operational routines and incorporate the prevention paradigm (Vickers & Cordey-Hayes, 1999). Many sectoral CP guides and manuals take this classification as their main structure[2] and distinguish among: (i) best practices as adjustments of operational procedures and planning practices, (ii) cleaner technology that requires identification, installation and operation of new equipment, and (iii) new activities that involve the creation of new organizational structures to handle preventive environmental activities.

The knowledge-based view of the firm (Grant, 1996), an extension of RBV theory, posits that the socially complex organizational processes created by human capital and organizational learning offer particularly strong competitive advantages because they are particularly difficult to imitate. Table 1 presents a summary of the two different cleaner production typologies.

[Table 1 here]

- Dissemination of CP in SMEs

Even though Hart´s (1995) theoretical perspective explains why firms should adopt CP for their own benefit, resistance to change and institutional barriers constrain dissemination among firms, especially small ones (Shi *et al.,* 2010; Baas, 2006; Granek, & Hassanali, 2006; Howgrave-Graham & Van Berkel, 2006). Hence, CP dissemination is of interest to government as a strategy to reduce the environmental impact of industries that is complementary to traditional environmental regulatory instruments (UNEP, 2004). Examples can be found in the adoption of CP policies by numerous national and regional authorities in Latin America (Leal, 2006), and the establishment of a global network of CP centers by multilateral organizations and development banks in more than 100 countries (Ehrenfeld *et al.,* 2002). The aim of these national and international initiatives is to persuade firms to adopt CP strategies on a voluntary basis.

[2] (i) Centro Nacional de Producción más Limpia de Honduras (CNPLH), 2009. Guía de producción más limpia para la industria textil, [Cleaner production guide for the textile industry] . Tegucigalpa, Repœblica de Honduras: AGA & Asociados, http://www.cohep.com/pdf/GUIA%20DE%20P+L%20TEXTIL.pdf , consulted May 2011; (ii) Centro Nacional de Producción más Limpia & Tecnologias Ambientales (CNPML&TA), 2009. Guía de producción más limpia para el sector de recubrimientos electrolíticos en Colombia, [Cleaner production guide for the plating industry in Colombia], Universidad Pontificia Bolivariana, Grupo de estudios ambientales, www.invemar.org.co/redcostera1/invemar/docs/RinconLiterario/2009/octubre/JE_64.pdf, consulted May 2011, (iii) Centro de Promoción de Tecnologías Sostenibles (CPTS),2005. Guía Técnica General de Producción más Limpia, [General technical cleaner production guide], La Paz, Bolivia, www.bolivia-industry.com/sia/novedades/GUIA_PML.pdf, consulted May 2011

The most common instruments used to influence CP adoption in SMEs are (Ehrenfeld *et al.*, 2002): offering subsidized technical assistance, providing information exchange through manuals and best-practice guides, training programs, public recognition of the environmental improvements of firms, cleaner technology funds, and voluntary agreements among industry leaders. These early demonstration-type approaches to CP have dominated the initiatives undertaken in Latin America (Jimenez, 2007; Blackman *et al.,* 2009; Van Hoof & Herrera, 2007; Grutter & Egler, 2004). Table 2 illustrates examples of CP dissemination programs developed in different parts of the world and their economic and environmental benefits, as reported in the literature. (Monetary values are converted to US dollars for consistency.)

[Table 2 here]

The financial and environmental indicators of the CP experiences shown in the table suggest the promise of CP for reduction of environmental contamination among this "hard to tackle" group of firms as well as its contribution to their individual competitiveness. Nevertheless, the effectiveness of these types of programs for CP dissemination has been questioned (Baas, 2006). Dieleman (2007) found that less that 40% of firms that received technical assistance in CP improved their performance. Stone (2006a) and Sage (2000) found even lower adoption rates. Moreover, technical assistance schemes involve payments to costly specialized consultants, and therefore make CP dissemination costly and hard to scale up.

Scholars have proposed alternative approaches to spur the adoption of CP measures by SMEs in emerging economies. Blackman (2006) suggested that they should use group approaches in order to impact a large and diverse collection of firms. Stone (2006b) and Vickers (2000) highlighted the importance of organizational learning as a key approach to cleaner production implementation. Seuring and Muller (2008), Carter and Rogers (2008), Srivastava (2007), Friedman and Miles (2002) and Sarkis (2002) introduced supply chain approaches as effective frameworks to engage suppliers in sustainability initiatives. Yet academic enquiry on the empirical effects of these types of mechanisms on CP dissemination among SMEs is still scant.

A combination of these alternative approaches was used in the design of a Mexican Sustainable Supply Program (MSSP) aimed at disseminating CP practices among SMEs. The CP projects designed by SMEs that took part in this program are the objects of this study.

3. Mexico´s Sustainable Supply Program

This section describes the organization and design features of the Mexican Sustainable Supply Program (MSSP) as the context in which the assessed CP initiatives were developed.

The MSSP was created in the context of growing international trade and difficulty controlling industrial pollution caused by SMEs in Mexico. The initiative was designed in 2005 by the Commission for Environmental Cooperation in

North America (CEC)[3], part of the North American Agreement on Environmental Cooperation (NAAEC). The program's main objective was the development of an innovative, replicable mechanism for the dissemination of sustainability practices among SMEs. In 2008, the Mexican Secretary of Natural Resources (SEMARNAT), as a member of the CEC Board, and Mexico's Federal Protection Agency (PROFEPA) undertook to promote the program on a national scale, as part of the National Development Plan of President Calderon's government. At this writing (March 2012), the program is still ongoing.[4].

The program design included certain state-of-the-art features of CP dissemination. The main elements of the program design may be summarized as follows:

A. *Public-private partnership to facilitate environmental management:* The CEC invited large private companies to collaborate in the engagement and improvement of the environmental performance of SMEs. CEC provided financial support for the operational cost of the pilot programs, and the privately-owned large companies committed to take part in the program by playing a facilitative role in engaging the efforts of the private sector.

B. *Supply chain power to reach out to SMEs participating in global supply chains and generate scale effects*: One of the main commitments of the large private companies was to select and invite a set of their suppliers (mainly SMEs) to participate in the program. Groups of participating firms comprised one leading company and about 10-15 suppliers (each of whom sent one or two participants to the program) corresponding to the production-chain units within the program. The large private "leading" companies had freedom to select which suppliers to invite.

C. *CP as pollution prevention applications*: CP-related strategies and tools were used to design pollution prevention alternatives in each production chain. A step-by-step approach started with the analysis of the strategic and competitive context of the firm, benchmarking successful cases and furnishing references to similar companies within the supply chain. To prioritize improvement options, eco-maps were elaborated[5]. The eco-balance tool and the calculation of inefficiency cost oriented the design of improvement options and their feasibility. Finally, all companies presented a pollution prevention alternative to improve the economic and environmental perspectives of their operations.

D. *Learning-by-doing approach to generate empowerment*: At the heart of the MSSP is a 10-step educational training program that emphasizes learning by doing. In this model, the participants themselves were required to

[3] www.cec.org

[4] http://liderazgoambiental.gob.mx

[5] Eco-mapping is a CP tool for identifying and prioritizing environmental impacts and resource consumption in a geographic area; eco-balance, or mass and energy balance, is another CP tool used to calculate efficiency of specific processes; inefficiency costing is an accounting technique that values the cost of waste and inefficiencies that occur in production processes (Van Hoof *et al*., 2008).

generate CP projects that contribute to increasing their productivity, competitiveness and environmental performance. In this way, the training method aims at capacity building and the empowerment of employees (Stubbs *et al.,* 2006) within each company as they "engage" their CP projects. Since leading companies as well as SMEs sent participants to the program, the class experience itself and networking between the participants provided a direct opportunity for establishing relationships between clients and suppliers. At the completion of each cycle of the program, there is a well-publicized ceremony to honor the participants and provide recognition for their efforts.

E. *Train-the-trainer to scale up*: In order to scale up the outreach of the program to include a significant number of SMEs, local consultants and technical assistance centers were trained in the learning-by-doing methodology. In this way, a network of service providers was developed throughout the country to train supply chain groups in the different states of Mexico. Service providers were generally entrepreneurial centers in universities or technology centers known for their close relations and experience with industry.

Execution of the MSSP occurred from August 2005 onwards; its pilot phase, led by the CEC, ended in May 2008. From this time on and up to March 2012, SEMARNAT and PROFEPA continued the program on a national level. The program design remained the same throughout the program.

The cost to operate the MSSP consisted of several components: costs involved in program management, payment of service providers who delivered the training program, logistical costs of the supply group meetings, and logistical costs involved in ceremonial activities such as opening and closing events. Program managers of CEC and SEMARNAT estimated total participation costs per supplier ranged from US $ 500 – US $ 1,500 per participating supplier.[6] The research for this paper drew on the program's database, in which the consolidated results and details of the CP design projects are registered.

4. Research methodology and database

The central focus of this study is to examine the costs and benefits of CP projects designed by small firms that participated in the MSSP and the variables that influence these outcomes.

This study used cost-benefit analysis as its main methodology to answer the first research question: What were the economic and environmental costs and benefits of CP applications designed in the Mexican Sustainable Supply Program? Cost-benefit analyses are commonly used by companies to take

[6] Operational costs to run the program were paid for by different actors. In the pilot phase of the program (2005 – 2008), CEC paid the cost of the service providers and assumed program management. In this phase, anchor companies assumed the logistical costs of workshop meetings and ceremonial activities. Later, SEMARNAT and PROFEPA took the role of program manager and financed the operational costs of the service providers and management. Anchor companies continued to assume the logistical costs for workshop meetings.

management decisions about projects (McLellan *et al.*, 2009; Souza *et al.*, 2009; Evans *et al.*, 2006; Nazer, 2006; Guo *et al.,* 2006; Dijkmans, 1999; Yang *et al.*, 1997). In the economics literature, cost-benefit analyses are also used for decision-making regarding public support for environmental programs and strategies (Hanley & Spash, 1993). These applications differ in their unit of analysis (programs vs. companies or specific projects), but share the same techniques (Ahlroth *et al.,* 2011).

The advantage of this methodology lies in the quantification of economic and physical material and energy flows resulting from sustainability efforts. The standard procedure of a cost-benefit methodology computes net present values (NPV) of specific actions (Hanley & Spash, 1993). Cost-benefit analyses often concern projects that have impacts in the future. This is especially important for prevention-oriented alternatives and programs where benefits are reaped from the "non-occurrence" of environmental contamination and related economic costs (Van Berkel, 1994). To compute the NPV of benefits and costs that occur in the future, discounting is used. The discount rate is typically described as consisting of two parts, the pure time preference rate and a factor linked to the growth rate of consumption and risk in a particular country (in this instance, Mexico) (Banks, 2010). Details for estimating the discount rate and the NPV method employed are presented in Appendix A.

Turn now to the second research question of this study: what company and project characteristics influenced the program outcomes? The analysis considered NPV as the dependent variable and firm characteristics and project types as independent variables. The relationships between the independent and dependent variables were analyzed using ordinary least squares (OLS) estimators. This method permits analysis of the individual effect of project types, controlling for firm characteristics such as sector type and firm size. The estimations characterize projects using three categorical variables: Firm Size, Type of Provider, and Project Typology. Model 1 uses Typology 1 presented in Table 1, while Model 2 uses Typology 2. Each of the foregoing variables has one omitted reference category to prevent multicollinearity (Gujarati, 2004; Gulati *et al.*, 2009). Table 3 presents the variables, together with the full list of categories employed for each variable, and the reference category.

[Table 3 here]

The natural logarithm of the NPV and the square root of the paybacks were used to reduce heteroskedasticity resulting from differences in firm sizes (Hanssen & Asbjørnsen, 1996). Separate models were elaborated to analyze the different typologies described in the research framework and STATA 7.0 was used to run the regressions. For a given firm *j*, the models estimated were:

Model 1

$$\ln NPV_j = \alpha_0 + \sum_{i=1}^{3} \beta_i * Firm\ Size_i + \sum_{i=1}^{4} \gamma_i * Type\ of\ Provider_i + \sum_{i=1}^{2} \delta_i * Typology\ 1_i + \varepsilon_j$$

$$Square\ root\ Y_j = \alpha_0 + \sum_{i=1}^{3} \beta_i * Firm\ Size_i + \sum_{i=1}^{4} \gamma_i * Type\ of\ Provider_i + \sum_{i=1}^{2} \delta_i * Typology\ 1_i + \varepsilon_j$$

where separate regressions are conducted for:

$$Y = \begin{cases} Savings\ CO2 \\ Savings\ Water \\ Waste\ Material\ Savings \\ Raw\ Material\ Savings \end{cases}$$

Model 2

$$\ln NPV_j = \alpha_0 + \sum_{i=1}^{3} \beta_i * Firm\ Size_i + \sum_{i=1}^{4} \gamma_i * Type\ of\ Provider_i + \sum_{i=1}^{4} \delta_i * Typology\ 2_i + \varepsilon_j$$

$$Square\ root\ Y_j = \alpha_0 + \sum_{i=1}^{3} \beta_i * Firm\ Size_i + \sum_{i=1}^{4} \gamma_i * Type\ of\ Provider_i + \sum_{i=1}^{4} \delta_i * Typology\ 2_i + \varepsilon_j$$

where separate regressions are conducted for:

$$Y = \begin{cases} Savings\ CO2 \\ Savings\ Water \\ Waste\ Material\ Savings \\ Raw\ Material\ Savings \end{cases}$$

Program database

The program database contains information about all the companies that participated in the program from August 2005 to April 2011. In total, the database contains information on 119 supply chain groups covering 1,044 companies (72 leading companies + 972 suppliers). The database includes a detailed description of their characteristics, as is discussed further below.

The data were gathered from different sources. First, all firms participating in the program filled out an intake form, reporting general features such as their main activity, number of employees, sector they belong to and information about the number of participants from their firm taking part in the program. Another important source of information is the final presentation of the project(s) designed as a result of the ten-step training program. These presentations contained detailed information about the type of CP alternatives to be implemented, estimated investments, and expected economic and environmental benefits.

All information was registered in the program database. Projects were coded using two different methods of classification, as described in section 2. The companies were also classified regarding the type of good or service they supply, such as packaging, printing, raw materials, indirect supplies[7] and services. Descriptive statistics of the main database characteristics are presented in Appendix B.

The different supply chain groups covered 22 of Mexico's 32 states. The regions where most groups participated were Mexico City and Queretaro. A total of 72 leading companies participated together with 972 suppliers, with several leading firms participating in multiple iterations of the program. These multiple group participants included Alpura (milk products), Grupo Modelo (beer), Jumex (foods), Nestle (foods), and Bristol Myers Squibb (pharmaceuticals). Ninety-five percent of the suppliers are classified as small and medium-sized companies. On average, two persons from each company participated in the training program. In total, participating supplier companies formulated 1,934 projects, which represents our population for purposes of analysis. Of the original database, 148 observations (projects) were withdrawn, due to incomplete information in their reports. The 72 participating leading companies formulated a total of 202 CP projects themselves. Benefits from these projects are calculated separately in this study and are not included in the regression analyses, as the leading companies are not SMEs.

The next section presents the results of the cost-benefit analysis. It begins with the cost-benefit analysis of the overall program, then turns to the supply chain groups, the firms, and the individual projects. Results of the sensitivity analysis follow.

5. Results

Table 4 shows the NPV of the program, the supply groups, the firms and projects resulting from the MSSP. The results from the CP projects designed by the leading companies are not taken into account in the calculation as the focus of this study is on the suppliers participating in the MSSP.

[7] Materials, purchases and supplies used in the operation of the business, that are not directly associated with production and are part of operating expense (Choi & Hardly, 1996).

The total NPV of the planned economic benefits of the program (ignoring benefits to the leading companies that participated) is $157 million[8]. The arithmetic mean per supply chain group is $1.32 million; per supplier company, $161,000: and per project, $81,000. These figures reveal the attractiveness of the projects. Most projects presented simple payback periods (time to recoup the initial investment) estimated at one year or less. The relatively large standard deviations shown in the Table illustrate the great diversity in types of projects and potentials of specific groups and firms.

The administrative costs to operate the MSSP were subtracted from the NPV calculations, as were the required initial investments. As explained at the end of section 3, most of the logistical costs to operate the program were assumed by leading companies and not quantified even in terms of the time dedicated by the participants in the program. Furthermore, the results in the table show how the average NPV of projects has risen and fallen over time. However, it is notable that results per project in 2011 were still 33% higher than in 2006, despite the fact that the number of suppliers involved was more than an order of magnitude greater.

[Table 4 here]

Table 5 presents the environmental benefits of the program as a whole. The table distinguishes between energy savings, water savings, waste-reduction and raw material prevention. Yardsticks used are adjusted to Mexican realities (such as average family size, per capita water consumption, and per capita waste generation). Values were computed taking into account the lifetime of the projects, with duration depending on its type between 3 – 5 years[9].

[Table 5 here]

As mentioned above, the large standard deviations of economic benefits imply considerable heterogeneity among the different types of projects. To deepen understanding of the benefits generated, the relationship between types of projects and NPV, and between types of projects and payback periods, were analyzed. Figure 1 illustrates that payback periods for most of the projects are less than one year.

[Figure 1 here]

Figure 2 provides insights into the NPV of different types of CP applications using box plots. Differences in NPV are shown for projects classified as best practices, new activities, and technology innovation. New activity projects offer a higher NPV than projects classified as either best practices or technology innovations. Boxplots show the distribution of data in a graphical way. The

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[8] All figures are reported in US dollars. Exchange rate: $ 1 US Dollar = $ 12.2687 MXP; www.exchange-rates.org (August 5, 2011)

[9] These time periods depend of the type of projects designed, such as best practices, process adjustments, new technology, and waste recycling. The following expected durations were used in the calculations: best practice, 3 years; process adjustment, 3 years; technology change, 5 years; waste recycling, 5 years (Gradl *et al.,* 2009; Hegde *et al.*, 2000).

shaded boxes represent one standard deviation above and below the line crossing the middle of the box, which shows the median value. The crossbars at the top and bottom of each line represent two standard deviations above and below the mean. In this way, the figures present normal distributions of the NPV of the different typologies. The points outside the box crossbars represent outliers. Outliers in Figure 2 mainly appear in the best practices category, which spans a relatively broad range of preventive alternatives.

[Figure 2 here]

The second typology of project classifications is illustrated in Figure 3. Projects involving combined environmental savings[10] show a higher average NPV than other types of projects. Projects involving CO_2 savings and water show a lower NPV than those involving raw material savings and waste recycling. (The differences do not appear statistically significant in the Figure, but we have not yet controlled for other factors, as we will do in the statistical analysis below.) One interpretation of these observations is that the costs of energy and water use in Mexico are relatively low compared to the costs of raw materials and waste management. The latter two types of costs are related, insofar as waste recycling may imply raw material savings, as inputs are re-used. Projects involving water savings appear the least attractive in terms of economic benefits; these types of projects generate a lower NPV and longer payback periods than other projects. Perhaps the explanation lies in the subsidized water prices that make this resource relatively cheap in comparison to other resources. Outliers in Figure 3 related to water efficiency can be explained by the relatively small variance in this category and the comparatively small number of observations in the database featuring water efficiency projects.

[Figure 3 here]

To analyze the statistical significance of the patterns suggested by Figures 2 and 3, a linear regression analysis was conducted, controlling for supplier type and firm size. The results of the regression analyses are shown in Table 6 (Model 1) and Table 7 (Model 2). Model 1 differs from model 2 by taking into account different typologies of CP projects in the regression estimation. The results of the regression analyses were consistent with the findings depicted in Figures 2 and 3.

Project typology 1: Findings presented in Table 6 confirm the interpretation of Figure 2. That is, projects classified as technological innovation and new activities feature significantly higher NPV than best practices (our reference category). Technology innovation projects also feature significantly higher CO_2 savings than best practices. This is to be expected, as these types of projects include structural adjustments – for example, redesign of lighting systems, installation of capacitor banks, or replacement of existing machinery. Projects classified as new activities show significantly lower CO_2 benefits than best practices, although new activities produce significantly greater water savings, waste savings and raw materials savings. As these results suggest, best

[10] Combined savings programs involve at least two types of savings: CO_2, water, waste reduction and/or raw materials.

practices often include energy savings related to CO_2 reduction, while new activities mainly include valuation of waste streams.

[Table 6 here]

Table 6 also provides interesting insights into the role of firm size, with the general result being that the smaller the company, the smaller the NPV of its projects. For micro-, small- and medium-sized firms, table 6 shows statistically significant differences with our reference group "large-sized firms." Negative coefficients indicate a significantly lower NPV as compared to large firms. A similar trend is observed for environmental benefits. For water savings, a reduction in firm size results in smaller water savings. Surprisingly, micro-sized firms formulated projects with slightly larger CO_2 savings than companies identified as small firms. Another statistically significant relationship is that projects designed by medium-sized firms that participated in the program generated less raw material savings than larger firms that designed similar projects.

The table also provides insight into the effects of supplier type on project characteristics. Firms classified as providers of indirect supplies, and firms providing services generated lower economic benefits than suppliers of industrial parts (the reference category). A partial explanation of these results may be that most service providers designed small projects in their internal operations (for example their own physical plant). Most of them did not redesign or improve services such as cleaning, consultancies, and transportation, which could have represented higher potentials for economic savings. With respect to environmental benefits, raw material suppliers designed projects with significantly higher CO_2 savings than industrial parts suppliers (the reference category). An explanation may be that the transformation processes used to deliver raw materials require on average more energy resources than does the industrial parts production process. Projects of indirect suppliers resulted in significantly larger raw material savings than suppliers of industrial parts.

Project typology 2: The regression results in table 7 confirm the general picture presented in Figure 3. Projects focused on combined savings produced significantly higher economic benefits than projects that focus on any single benefit, be it energy efficiency, water efficiency, raw material efficiency, or waste recycling. The coefficients in Table 7 indicate the order of value of the various types of projects: prevention-oriented projects involving material savings resulted in higher economic benefits than waste recycling, energy efficiency, or water savings. The project typology used in model 2 shows consistent results with environmental savings in the sense that energy efficiency projects are positively related to CO_2 savings, and water efficiency projects are positively related to water savings. Unlike CO_2 and water, which represent homogeneous indicators of project savings, waste reduction and raw materials represent a range of different types of materials and wastes with diverse volume-value ratios.

Results for firm size, and for supplier type, are consistent with those in Table 6. Smaller firms generate projects with lower NPV, and lower CO_2 and water savings. Companies providing indirect supplies or services generated projects with significantly lower NPVs than did companies producing industrial parts (the reference group). The next section discusses the aforementioned findings in light of the research questions guiding this study.

[Table 7 here]

6. Discussion

The findings of this research confirm significant economic and environmental benefits from CP projects designed and put in place under the Mexican program, and provide insights on the variables influencing these economic and environmental outcomes. Both typologies for CP applications used in this analysis provided significant explanatory power in characterizing the NPV for different types of projects. Thus, the findings confirm the relevance of the classifications for the evaluation of CP dissemination programs such as the Mexican case. Moreover the results show how SMEs in an emerging country can contribute to significant economic and environmental benefits within global supply chains if the right context is created.

The majority of projects feature paybacks of one year or less. Also, 94% of the designed CP projects presented positive NPVs. Divergence of paybacks across different types of projects appears relatively small; virtually all of them pay back quickly. Yet projects identified as new activities, (which in most instances involve waste recycling), are in economic terms the most beneficial as they require relatively small investment and result in high rates of return. Projects classified as technology innovations feature higher economic and environmental benefits than projects identified as best practices. Most observations of best practices are related to energy efficiency projects. It is somewhat surprising that these projects present lower NPVs. A possible explanation is that subsidies of electricity prices for small and medium sized industrial consumers (up to 10% depending the year of analysis[11]) (INEGI, 2010) lowers the value of conducting energy efficiency projects. In addition, the relatively low costs for industrial use of water in Mexico, ranging from 1 – 5 cents per cubic meter[12], contribute to relatively low NPVs for water saving projects.

Furthermore, the results show how the average NPV of projects designed in the program has risen and fallen over time. This suggests the presence of some learning effects in the rollout of the program, and diminishing marginal returns as the program has scaled up. However, it is notable that results per project in 2011 were still higher than in 2006, despite the fact that the number of suppliers involved was more than an order of magnitude greater. This suggests that diminishing marginal returns may not be a major problem for the program, particularly if new leading companies are brought into the program. Further research will be needed to clarify these initial thoughts about the dynamics that occurred during the rollout of the MSSP.

[11] Electricity cost for industrial use oscillates around 1 cent per KwH. (www.cfe.mx)
[12] www.conagua.gob.mx/CONAGUA07/Noticias/Edomex.pdf

This information about the outcomes of cleaner production projects makes it possible to focus the tools and cases applied in the training program of the MSSP in a way that particular results, such as economic or certain types of environmental benefits, can be maximized. The short payback periods and attractive net present value of the projects also suggest that there are still available numerous “low-hanging fruits” (Van Berkel, 1994) from optimizing the efficiency of supply chains participating in the program.

The findings strongly suggest that firm size is positively related to economic and environmental benefits. Larger firms design projects with larger economic and environmental impacts. This suggests lessons for SEMARNAT and other leading Mexican institutions and companies participating in the program: search out other large upstream supplier companies as further efforts toward environmental progress in supply chains are pursued; conversely, more modest results must be accepted to the extent program participants consist mainly of smaller companies.

The effect of supplier type on environmental benefits is less clear. This research only shows a few significant outcomes with regard to supplier type in relation to CO_2 and water savings. Projects designed by printing firms and indirect supplies have significantly smaller environmental savings. Firms identified as printing and raw material suppliers generate, on average, projects with greater economic benefits than providers of indirect supplies and services. Accordingly, this research provides some guidelines for selecting suppliers to be invited in future initiatives of a similar nature.

The wide range of different projects designed by diverse firms illustrates that CP tools, such as eco-maps, eco-balances, and inefficiency cost, apply to a wide range of different-sized enterprises in different lines of business. The SMEs were able to create tangible knowledge-based advantages using CP. This finding contrasts with that of Jenkins (2004), who bemoans the lack of tailor-made tools and strategies for environmental improvement in SMEs. Comparing this study´s outcomes with Jenkins’ argument, it appears that the strategy used for dissemination, and not the tools themselves, was the most important factor in achieving improved dissemination of environmental improvement among SMEs.

The cost-benefit outcomes of the CP projects designed in the MSSP compare favorably to findings reported in the literature on CP dissemination efforts in other parts of the world (Ruvalcaba *et al.*, 2005, Nazer, 2006, Hong Nhat, 2007, CNPML&TA, 2009, Gradl *et al.*, 2009). Paybacks are similar to the cleaner production applications reported in table 2, and NPVs were significantly larger. An explanation might be found in the average size of the firms. An additional hypothesis considers the different dissemination mechanisms used in the different efforts. Most prior efforts relied primarily on technical assistance from specialized external consultants; in contrast, the MSSP used a learning-by-doing method in which job-floor personnel identified and designed for themselves viable CP projects. Further research should examine how the MSSP method performs in terms of known barriers to CP dissemination in

SMEs, such as the lack of technical know-how and information about attractive practices and technologies (Van Berkel, 2006; Grutter & Egler, 2004; Hilson, 2000), and lack of empowerment and motivation of staff involved in the development and implementation of preventive alternatives (Stone, 2006b; Baas, 2006).

The results of the MSSP suggest that the use of "supplier power" to reach out to a significant group of local SMEs and larger providers is a promising strategy. In less than six years, the Mexican initiative reached out to more than 972 supplier firms nationwide. This interpretation echoes Blackman (2006), who proposes group approaches as strategies to connect SMEs in developing countries to sustainability actions. Group approaches bring down the costs of technical assistance and information dissemination in CP, and strengthen organizational capacity for collaboration and information exchange, which helps to create tangible knowledge-based advantages within the perspective of the NRBV (Hart, 1995). The idea of using client-supplier relationships to involve SMEs also seems promising as a way to overcome the lack of external pressures from stakeholders, which has been identified as a main limitation for decision-making towards environmental improvement of small firms (Baas, 2006; Grutter & Egler, 2004).

In addition to the benefits obtained through the dissemination of CP applications in supplier firms, the leading companies that participated in the MSSP also formulated a significant number of CP projects. These also offered significant environmental and economic benefits, as firm size is positively related to the scale of their improvement options. Nevertheless, because the focus of this study is on SMEs, the projects initiated by leading companies are not included in the analysis.

The analysis in this study focuses on "internal" NPV understood as tangible financial benefits internalized to the balance sheet of the firm that designed the CP projects. It is somewhat surprising that the internal NPVs are highest for waste management and new activity, rather than energy efficiency or new technology. The first two mostly involve applications where supplier and leading company collaborate. Milstein, Hart and York (2002) identify other "intangible" values of sustainability investments that result from network relationships and learning effects. In this study these network and learning effects are not evaluated, but the reasoning of Milstein, Hart and York (2002) suggests that the intangible aspects of these collaborative efforts would be higher than for non-collaborative projects. Thus, waste management projects in the supply chain, in programs comparable to MSSP, are expected to be the most attractive CP applications.

Finally, the results illustrate how a voluntary CP-based mechanism developed by means of public-private partnerships can generate significant environmental improvements. The aggregate environmental benefits of the program would neutralize the environmental impacts generated by a small city with a population of about 40,000. Moreover, the economic benefits of the program expressed in

NPV are equivalent to the annual minimum wage of 170,000 [13] Mexican citizens.

Accordingly, voluntary mechanisms stand to play an important role for environmental policy implementation in developing countries (Blackman, Lyon and Sisto, 2006). The basic idea behind these mechanisms is that the role of government may usefully be changed from being interventionist to playing a more facilitative role, encouraging efforts by the private sector itself (Frijns & Van Vliet, 1999). The significant scale of the aggregate benefits of the MSSP supports this argument. Furthermore, a voluntary mechanism such as that employed for the program opened opportunities for both public and private institutions to communicate indicators of environmental quality improvements. Often, regulatory and economic agencies only report indicators related to administrative processes (Espinosa & Rodriguez, 2003; Romo, 2005).

7. Conclusions

This research assesses the economic and environmental performance of an innovative program aimed at small and medium-sized enterprises (SMEs) included in supply chains of major manufacturers in Mexico. Known techniques such as cost-benefit analysis and linear regression models are used to study relationships between firm and project characteristics, and economic and environmental outcomes.

The study's database includes a large sample of companies in comparison with other quantitative studies involving SMEs (Kusyc & Lozano, 2007). Information contained in the database is chiefly drawn from that made available by the participating companies regarding the CP projects they designed. The database does not contain information concerning the implementation rate of these projects. This is unfortunate, and a key limitation, as several CP programs report limited application percentages despite the attractive economic and environmental benefits of the designed alternatives (Stone, 2006a). It is recommended for further research to assess the implementation rates of the designed projects and their real economic and environmental benefits.

Although numerous insights were gleaned concerning program effects on participating companies, this study does not consider the organizational dynamics that occur within and between companies. Future research on the profiles of participants and the interaction among them would be worthwhile. Furthermore, we were not able to identify the role of government subsidies in making energy and water conservation less profitable than waste reduction. The study of contextual variables such as energy and water prices and waste disposal tariffs, and their influence on the economic and environmental benefits of CP initiatives is recommended as an important field of inquiry for future CP dissemination efforts.

[13] www.sat.gob.mx

The database used in this study concerns firms linked to global supply chains. In the context of an emerging economy such as Mexico, these types of companies are generally classified as more advanced (Battat *et al*., 1996; 20). However, microenterprises, with less than 10 employees, represent far and away the largest category of SMEs in Latin America (Zevallos, 2003). Few of these firms deal directly with global supply chains. Nonetheless, they play an important role in the local economic context and represent a significant source of environmental pollution. Reaching out to the region's vast number of microenterprises and searching for ways to reduce the impact of their operations on the environment remains an important challenge for researchers and practitioners (Schaper, 2002).

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Appendix A: Analytical Approach used in the Net Present Value (NPV) calculation

Net Present Value (NPV) is a standard financial indicator to analyze the profitability of an investment project, taking into account the time periods of investment and returns, and future cash flows. Its procedure involves aggregating the initial investment cost and a calculation of the overall value of a project as if that value were obtained at once in the present, summing up the annual incomes over the time period that the project will be in place. Discount rates are used to reflect the time value of money.

The general formula to compute NPV indicators is (Banks, 2010):

$$NPV = \sum_{t=1}^{n} \frac{V_t}{(1+k)^t} - I_0$$

where:

- *NPV* represents net present value
- V_t represents the cash flow in period t.
- I_0 is the initial investment.
- *n* is the number of periods considered in the project.
- *k* is the discount rate.

As the main reference to establish the appropriate discount rate, we use Villareal (2010), who proposes a consistent methodology for the calculation of the cost of capital in emerging markets such as Mexico. This method, which relies on the Capital Asset Pricing Model (CAPM), uses the following assumptions:

Discount rate = $K_D'(1-\tau) + \beta_L[(R_m - R_f) + CR]$

where:

$K_D' = debt\ costs\ before\ taxes = R_f + intermediation\ spread + CR$

R_f =interest rate without risk

Intermediation spread = margin depending of the country risk of Mexico (BBB)

CR = country risk as evaluated by Standard & Poors

τ =tax rate of the Mexican market

$(R_m - R_f)$= risk premium, derived from the differences on the simple averages of the rates in the market and the spot rate for the zero-coupon bonds of the US treasury.

β_L= Beta of leveraged assets, calculated from the average assets of sectors, discounted at the average of the optimum capital structure of the sectors (D/E) and the Mexican tax rate.

Sources:

R_f:
US Department of The Treasury (2011). Daily Treasury Yield Curve Rates. Consulted 25 th of May 2011 in http://www.treasury.gov/resource-center/data-chart-center/interest-rates/Pages/TextView.aspx?data=yield

Intermediation spread:
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Appendix B Descriptive statistics of the MSSP database

Items	Value	Standard Deviation
Number of supply groups		
• Total	119	
Geographic coverage of supply groups		
• Number of Mexican States involved	22	
Number of leading firms	72	
• Multinationals (origin)	59	
• Mexican (origin)	13	
Number of suppliers	972	
• Micro enterprise < 10 employees	56	
• Small enterprise 11 - 50 employees	271	
• Medium enterprise 51 - 250 employees	360	
• Large companies >250 employees	285	
Type of suppliers		
• Packaging materials	114 (12%)	
• Printing materials	63 (6%)	
• Raw materials	419 (43%)	
• Indirect supplies	105 (11%)	
• Services	271 (28%)	
Number of participants		
• Total	2,025	
• Per supply chain	18.24	7.7
• Per company	1.95	1.36
Number of projects designed by supplier firms		
• Total	1,932	7.56
• Per supply chain	16.23	1.23
• Per company	1.99	
Number of projects designed by leading firms		
• Total	220	
• Per company	3.05	
Planned investments ($ US)		
• Total	$ 48,331,173	
• Per supply chain group	$ 405,971	$ 948,847
• Per company	$ 49,733	$ 255,119
• Per project	$ 25,016	$ 167,570
Number of projects per typology 1		
• Best practice	1,218 (63%)	
• Technology innovation	603 (31%)	
• New activity	111 (6%)	
Number of projects per typology 2		
• Energy efficiency	874 (45%)	
• Water efficiency	300 (15%)	
• Raw material efficiency	236 (12%)	
• Waste recycling	306 (16%)	
• Combined savings	216 (11%)	
Average NPV of projects in year of participation ($ US)		
• 2006	$ 43,354 (n = 28)	$ 75,264
• 2007	$ 49,987 (n = 41)	$ 144,382
• 2008	$ 98,996 (n= 192)	$ 263,472
• 2009	$ 128,831 (n= 447)	$ 431,335
• 2010	$ 62,548 (n = 877)	$ 262,312
• 2011 (Jan – April)	$ 62,784 (n= 347)	$ 155,200

Table 1. Different typologies used to classify CP applications

Classification criteria	Typologies	Examples
Environmental gains	• Energy efficiency • Water savings • Raw material savings • Waste recycling	• Stand-by mode of electric appliances • Irrigation optimization of green areas • Optimizing inventory planning • Re-use of valuable sub-products
Level of innovation	• Best practices • Technological innovation • New activities	• Adjustment of operational procedures • Change of the complete lighting system of the plant • Recycling unit that upgrades by-products for new clients

Table 2: Economic and Environmental Benefits of Several CP Dissemination Efforts Targeting SMEs

Dissemination effort	**Cleaner production applications**	**Country**[g]	**Required Investment ($ US)**[h]	**Financial indicators** - **NPV ($US)** - **Payback**	**Other indicators of benefits**
Profitable environmental management ("Gestión ambiental rentable GAP")[a]	Varied (best practice 50%, small technology innovation 50%)	Mexico	Between 0 – $ 1,630	0.25 – 1 year	Water savings Raw material savings Energy savings
External technical assistance[c]	Re-use of chemicals in the leather tanning industry	Palestine	$190	$7,112	Reduction of water use 58% Reduction of chemicals 28%
External technical assistance[d]	Water recirculation in slaughter house	Vietnam	$ 4,409	$1,263	Water savings (20 – 35 %) Reduction of sewage (15 – 20%) Reduction of waste (10- 15%)
External technical assistance[e]	Steam recuperation in the boiler system through recirculation	Colombia	$ 5,400	$1,900	6% monthly reduction in carbon emissions
External technical assistance[f]	Water circulation in food industry	El Salvador	$250	$1,750 (annual savings) 0.3 years	580m^3/year water savings

[a] Ruvalcaba et al., 2005, [c] Nazer. D., 2006, [d] Hong Nhat.P. 2007, [e] CNPML&TA, 2009, [f] Gradl et al., 2009

[g] GDP per capita, in thousands of US dollars: Mexico, USD 10.153 (2011); Palestine, USD 1.483 (2009); Vietnam, USD 1.374 (2011); Colombia, USD 7.132 (2011); El Salvador,; USD 3.855 (2011); http://knoema.com/atlas/ranks/GDP-per-capita?gclid=CMnIs9y19rECFcGf7QodQwwA5w (august 20, 2012)

[h] Exchange rates: $ 1 USD = $ 12.2687 MXN; $1 Euro = $ 16.69 MXN www.exchange-rates.org (August 5, 2011)

Table 3. Firm and project characteristics influencing CP costs and benefits

Variable	Categories	Reference category
Type of supplier	• Industrial parts (metal parts, electronic parts) • Printing (printing and packaging) • Raw materials (chemicals, minerals, agricultural products) • Indirect supplies (office equipment, filters) • Services (cleaning services, maintenance, catering)	• Industrial parts
Firm size	• Large (>250 employees) • Medium (51-250 employees) • Small (11-50 employees) • Micro (< 10 employees)	• Large
Project typology 1	• Best practice • Technology innovation • New activity	• Best practice
Project typology 2	• Combined savings • Energy efficiency • Raw material efficiency • Water efficiency • Waste valuation	• Combined savings

Table 4. NPV of the planned economic benefits and payback periods of the CP projects designed by suppliers participating in the MSSP

Unit of analysis	Net Present Value ($ US)[a]	Standard deviation ($ US)	Payback (years)	Standard deviation
Whole program (August 2005 – April 2011) (n = 1)	$ 156,496,559			
Average per supply group (n = 119)	$ 1,315,424	$ 1,300,816	0.79	0.75
Average per supply firm (n = 972)	$ 161,993	$ 412,101	0.79	1.40
Average per project (n=1934)	$ 80,002	$ 288,536	0.77	1.64
Average per project (year of participation)				
- 2006	$ 43,354 (n = 28)	$ 75,264	0.78	1.24
- 2007	$ 49,987 (n = 41)	$ 144,382	1.04	1.68
- 2008	$ 98,996 (n= 192)	$ 263,472	0.80	1.67
- 2009	$ 128,831 (n= 447)	$ 431,335	0.55	1.02
- 2010	$ 62,548 (n = 877)	$ 262,598	0.88	1.82
- 2011	$ 62,784 (n= 347)	$ 155,200	0.73	1.79

[a] Assumptions made to compute NPV are shown in Appendix A

Table 5. Total value of environmental benefits of the CP projects designed by suppliers participating in the MSSP

Unit of analysis (whole program August 2005 – April 2011)	Value[a]	Yardstick [b]
• Energy savings (Ton CO_2)	1,102,145	214,564 cars taken of the road
• Water savings (m^3)	15,438,427	30,650 families of 5 members / year
• Waste prevention (ton)	465,017	Waste generation / year of a city of 1,274,020 inhabitants
• Raw materials conserved (ton)	426,292	

[a] The total value takes into account the expected life of each project. No discounting was employed.
[b] Yardstick based on data from SEMARNAT, 2010

Table 6. Outcomes of linear regression model 1

VARIABLES	NPV Model 1	Savings CO2 Model 1	Savings Water Model 1	Waste Savings Model 1	Raw Material Savings Model 1
Medium	-0.518***	-3.692***	-20.61***	-0.692	-0.678
	(0.0999)	(1.173)	(4.673)	(0.843)	(0.801)
Small	-1.079***	-7.455***	-25.62***	-0.322	-0.205
	(0.113)	(1.327)	(5.287)	(0.954)	(0.906)
Micro	-1.164***	-7.436***	-34.11***	-1.265	-1.990
	(0.209)	(2.461)	(9.802)	(1.769)	(1.680)
Printing	-0.210	-3.036	-1.362	-0.128	-1.048
	(0.209)	(2.443)	(9.730)	(1.756)	(1.668)
Raw material	-0.124	2.712*	6.897	1.595	0.364
	(0.135)	(1.587)	(6.321)	(1.141)	(1.083)
Indirect Supplies	-0.656***	0.216	-8.775	-0.460	-1.098
	(0.171)	(2.032)	(8.093)	(1.461)	(1.387)
Services	-0.479***	0.867	-4.418	1.093	-0.567
	(0.146)	(1.714)	(6.826)	(1.232)	(1.170)
Technology innovation	0.451***	6.255***	0.107	-0.884	-0.296
	(0.0920)	(1.068)	(4.252)	(0.768)	(0.729)
New Activity	0.513***	-6.145***	15.95*	4.683***	5.251***
	(0.176)	(2.123)	(8.457)	(1.526)	(1.449)
Constant	13.02***	10.35***	37.91***	2.329**	2.862**
	(0.139)	(1.630)	(6.493)	(1.172)	(1.113)
Observations	1,806	1,932	1,932	1,932	1,932
R-squared	0.087	0.047	0.026	0.010	0.010

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 7. Outcomes of linear regression model 2

	Logarithm of dependent variable	Square Root of dependent variable			
	NPV	Savings CO2	Savings Water	Waste Savings	Raw Material Savings
VARIABLES	Model 2	Model 2	Model 2	Model 2	Model 2
Medium	-0.544***	-4.355***	-18.75***	-0.638	-0.798
	(0.0995)	(1.082)	(3.986)	(0.807)	(0.784)
Small	-1.117***	-8.239***	-19.91***	-0.538	-0.406
	(0.113)	(1.223)	(4.507)	(0.912)	(0.886)
Micro	-1.238***	-7.815***	-25.18***	-1.151	-2.272
	(0.208)	(2.267)	(8.352)	(1.691)	(1.642)
Printing	-0.123	-1.173	-2.718	-0.381	-1.140
	(0.208)	(2.246)	(8.276)	(1.676)	(1.628)
Raw material	-0.0491	2.521*	2.291	1.965*	0.931
	(0.135)	(1.464)	(5.395)	(1.092)	(1.061)
Indirect Supplies	-0.605***	0.204	-9.693	-0.503	-0.929
	(0.170)	(1.870)	(6.891)	(1.395)	(1.355)
Services	-0.410***	0.208	-5.428	1.335	-0.0457
	(0.146)	(1.580)	(5.823)	(1.179)	(1.145)
Energy Efficiency	-0.625***	9.661***	-38.25***	-10.01***	-9.199***
	(0.137)	(1.499)	(5.524)	(1.118)	(1.086)
Water Efficiency	-1.115***	-9.979***	86.22***	-10.14***	-9.339***
	(0.162)	(1.763)	(6.498)	(1.316)	(1.278)
Raw Material Efficiency	-0.360**	-9.234***	-38.32***	-9.836***	-5.191***
	(0.168)	(1.857)	(6.841)	(1.385)	(1.345)
Waste Recycling	-0.603***	-9.471***	-39.23***	1.091	-2.877**
	(0.159)	(1.754)	(6.464)	(1.309)	(1.271)
Constant	13.73***	12.37***	53.65***	9.272***	9.479***
	(0.175)	(1.923)	(7.087)	(1.435)	(1.394)
Observations	1,806	1,932	1,932	1,932	1,932
R-squared	0.098	0.194	0.295	0.098	0.057

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

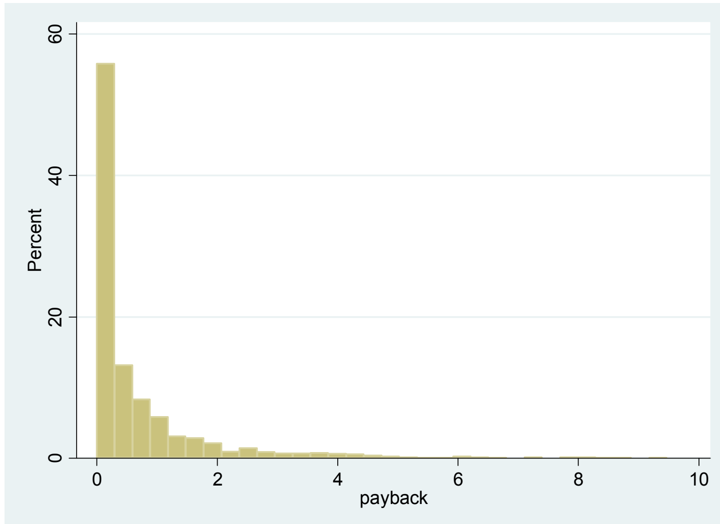

Figure 1. Payback periods of the cleaner production projects designed by the supplier firms in the MSSP

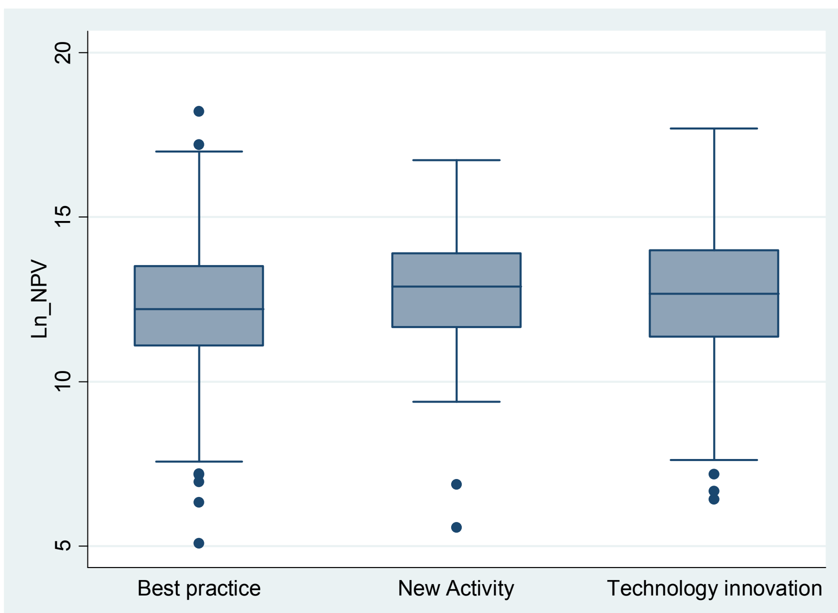

Figure 2. NPV of different types of CP projects developed in the MSSP (model 1)

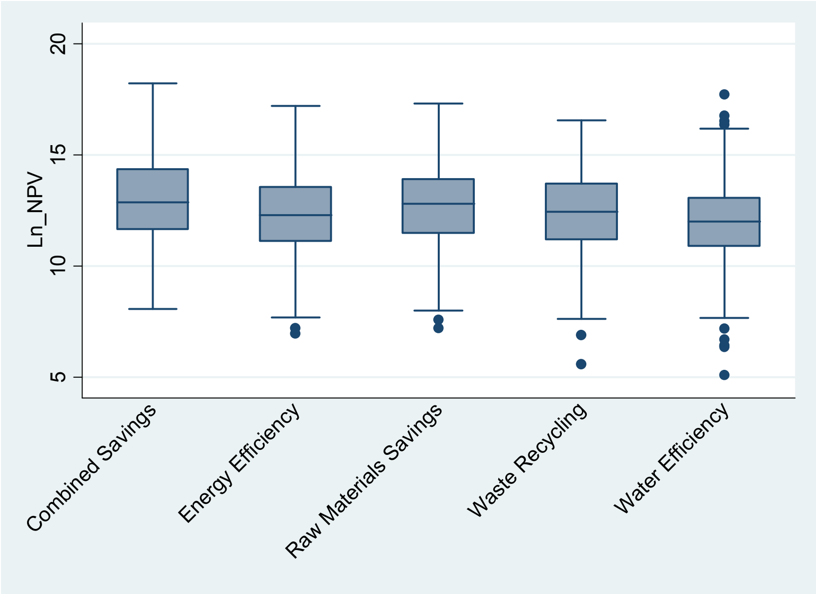

Figure 3. NPV of different types of CP projects developed in the MSSP (model 2)