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Using structural equation modeling to test environmental performance in small and medium-sized manufacturers: can SEM help SMEs?

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Abstract

Small and medium-sized enterprises (SMEs), defined as manufacturers employing 500 or fewer people, represent an estimated 70–98% of the manufacturing population globally and together have the potential to significantly impact the environment. Many of these small manufacturers throughout the world are not in compliance with environmental regulations, and even fewer see the need to focus on pollution prevention, implement environmental management systems, or to use life-cycle management or other proactive environmental management practices. A validated environmental performance model for SMEs holds the promise of providing a roadmap to more productive environmental results. This paper discusses structural equation modeling as a useful methodology to validate environmental performance models.

The paper shares some insights from the use of structural equation modeling, which was used to evaluate the development of an environmental performance model for SMEs. The model was based on the Malcolm Baldrige Criteria. We review SEM methodology and share results from a population of SMEs in the plastics manufacturing sector. Fit statistics confirmed the overall model fit, but not all of the paths in the model were statistically significant. An assessment of the non-significant paths (from leadership and from the system components of the model to environmental results) led the authors to conclude that an improved definition of environmental results is critical. Education of SMEs on the benefits of improved environmental performance is also warranted.

Keywords: SMEs; Structural equation modeling; SEM; Environmental performance; Education

1. Introduction

In aggregate, small and medium-sized enterprises (SMEs) can have a significant impact on the environment. Thus, SMEs must improve their environmental performance if existing and emerging environmental issues are to be effectively addressed. Yet SMEs will need assistance and models to improve their environmental performance. This paper discusses the use of structural equation modeling (SEM) to evaluate an environmental performance improvement model for SMEs.

"Command and control" regulations enacted over the last 30 years should be reinforced by other systematic, preventive programs to improve environmental protection. Additional environmental concerns, such as global climate change, resource depletion and species loss, have emerged and new issues will continue to be identified. These new challenges will require society, in general, and industry, in particular, to use new approaches to anticipate and prevent environmental stress. Companies must move beyond just complying with regulations to eliminating pollution and extending product responsibility.

2. Structural equation modeling: a method for testing SME environmental performance improvement models

Although it is not possible to instruct the reader on structural equation modeling (SEM), in detail, the following

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generally describes the process. The term structural equation modeling (SEM) approach refers to a series of statistical techniques used to analyze data [1–6]. Included in the series are path analysis,[1] confirmatory factor analysis,[2] structural regression models[3] and latent change models.[4] SEM consists of two components, a measurement model and a structural model. For this project, the measurement model includes the relationships between the dimensions (environmental performance model sub-categories) and the questionnaire items (indicators). The structural model shows the direction and strengths of the relationships of the variables.

Structural equation modeling is appropriate for data in which a series of regressions are being performed; the dependent variable for one regression analysis is also the independent variable for another [4]. The SEM method is most appropriate when theory or a priori guidelines allow the researcher to posit the relationships among the variables in the model.

Although SEM is a family of techniques, they all share the same basic analytical sequences [1,4]. The steps are briefly described as follows [4]:

a. *Specify a theoretically-based model.* The researcher expresses his/her hypothesis in the form of a structure model, which can take the form of a picture or series of equations.
b. *Construct a path diagram of causal relations.* The investigator defines the exogenous and endogenous constructs and links relationships in a path diagram.
c. *Convert the path diagram into a set of structural and measurement models.* At this stage the researcher specifies the model in more formal terms. This is done through a series of equations that define structural equations linking constructs; the measurement model specifying which variables measure which constructs; and a set of matrices indicating hypothesized correlations among the constructs or variables.
d. *Choose the input matrix type and estimate the proposed model.* At this stage the investigator has to confirm that the assumptions of SEM (independent observations, random sampling of respondents, linearity of relationships and multivariate normality) address missing data issues and determine if the model will use covariance matrices or correlation matrices for data input. (Covariance matrices are preferred, and if only a correlation matrix exists, the computer software uses mean and standard deviation of the data set to calculate the covariance matrix.)
e. *Assess the structural model.* A model is identified to determine if there are sufficient equations to "solve" each of the coefficients (unknowns) to be estimated. The researcher desires to have an over-identified (more equations than estimated coefficients and degrees of freedom greater than zero) model.
f. *Evaluate the model fit.* Use goodness-of-fit measures to determine how adequately the model accounts for the data.
g. *Interpret the results and, if necessary, modify the model.* Several Windows-based software programs are available for structural equation model analysis. For this project, LISREL 8.54 software was used. LISREL, an acronym for *LI*near *S*tructrural *REL*ations, is the name used by Jöreskog and Sörbom [7] for a widely used SEM software program.

Structural equation modeling can be used by universities, government agencies and larger companies to validate environmental performance models.

3. Environmental awareness and performance of small manufacturers

The definitions of an SME vary from country to country. The authors used an American definition of SME, which includes companies employing fewer than 500 people.

3.1. Importance of SMEs to the economy and the natural environment

Compelling evidence supports the growing importance of the SME sector in the world economy [8], with SMEs representing an estimated 70–98% of businesses worldwide, with percentages on the high side (>95%) being cited most frequently [9–15]. Because SMEs represent a significant element of the economy, they may have a considerable impact on the environment. Individually, SMEs may have limited impact on the environment, but in aggregate, their impact is believed to be significant [10,16–18].

Many SMEs do not comply with environmental regulations [10,16,19], and few SMEs have adopted environmental management systems [21–23]. Most managers and employees of small businesses profess a high level of environmental concern, but they have little knowledge of developments in the field of environmental management and have not introduced formal practices to manage the environmental performance of their operations [12,21–24,26,27]. Many small businesses are not aware of the cost of regulatory compliance, the expense of using hazardous materials or the price of inefficient processes in their operations [28]. Because most SMEs do not understand the true costs of compliance, cost reduction is not a motivator. Small manufacturers do not recognize that environmental enhancements can improve efficiency, reduce costs and increase profits [18,29].

[1] Path analysis is a method that employs simple bivariate correlations to estimate the relationships in a system of structural equations. The method is based on specifying the relationships in a series of regression-like equations that can be estimated by determining the amount of correlation attributed to each effect in each equation simultaneously.

[2] Confirmatory factor analysis: the use of multivariate techniques to test (confirm) a pre-specified relationship among several constructs.

[3] Structural regression models resemble confirmatory factor analysis models, except that they also postulate specific exploratory relationships (latent regressions) among constructs. The models can be used to test or disconfirm proposed theories about explanatory relationships among latent models under investigation.

[4] Latent change models represent a way to study change over time. The models focus primarily on patterns of growth, decline, or both in longitudinal data and enable researchers to examine both the inter-individual differences in patterns of change.

Despite the benefits of pollution prevention, SMEs have been slow to accept pollution prevention approaches. For example, only 28% of SMEs in Australia were familiar with cleaner production practices [30]. SMEs often lack the technical expertise and modern equipment needed to implement pollution prevention programs [14,28]. Firms with greater resources are more likely to incorporate pollution prevention innovations [18,31,32]. Consequently, larger firms are much more likely than smaller firms to take advantage of pollution prevention opportunities.

Small companies have limited resources and limited expertise and need environmental support tools [33,34]. SMEs will implement cleaner technologies when supported by individuals or organizations that SMEs deem credible [26,35–37]. SMEs respond to applied assistance from local authorities, universities, environmental groups and business organizations that provide assistance through help lines, seminars, publications or counseling visits [29,38–40]. Small businesses need tailor-made management systems [21,26] that are simple, inexpensive and requiring low maintenance, minimal paperwork [26,36].

4. An environmental performance model for SMEs

An environmental performance model based on the 2001 Malcolm Baldrige Criteria for Performance Excellence was developed by the authors and is described in the following paragraphs. The environmental performance model is shown in Fig. 1.

4.1. Creation of the Baldrige Criteria (Public Law 100–107)

The Baldrige Criteria are based on a set of core values, seven model elements and 18 sub-elements and concepts. The core values include visionary leadership, customer-driven excellence, organizational and personal learning, valuing employees and partners, agility (i.e., the capacity for rapid change and flexibility), focusing on the future, managing for innovation, management by fact, public responsibility and citizenship, focusing on results while creating value, and a system's perspective [41]. The core value of "public responsibility and citizenship" includes protecting the environment, adopting a product life-cycle approach, conserving resources and reducing waste, designing environmentally responsible products and moving beyond mere compliance with local, state and federal regulations [41]. The seven model elements include leadership, planning for continuous improvement, customer and supplier involvement, human resource focus, process management, information and analysis and results. Today, the Baldrige Criteria are essentially a global model of performance improvement since numerous countries have adopted similar criteria for business excellence [42].

4.2. Roles of the Baldrige Criteria

The Baldrige Criteria for Performance Excellence have three important roles: (1) improvement of organizational performance practices, capabilities and results; (2) facilitation of communication and sharing best practices information; and (3) use as a tool for understanding and managing performance, and for guiding planning and learning opportunities [41]. Environmental management is a subset of business management.

In order to validate the Baldrige Criteria as a tool for improving environmental performance and to establish the model as an improvement tool specific to environmental performance, it was necessary to modify some of the categories, items and program elements. Changes were made to the appropriate categories to incorporate the product life-cycle thinking and focus on environmental impact reduction. For example,

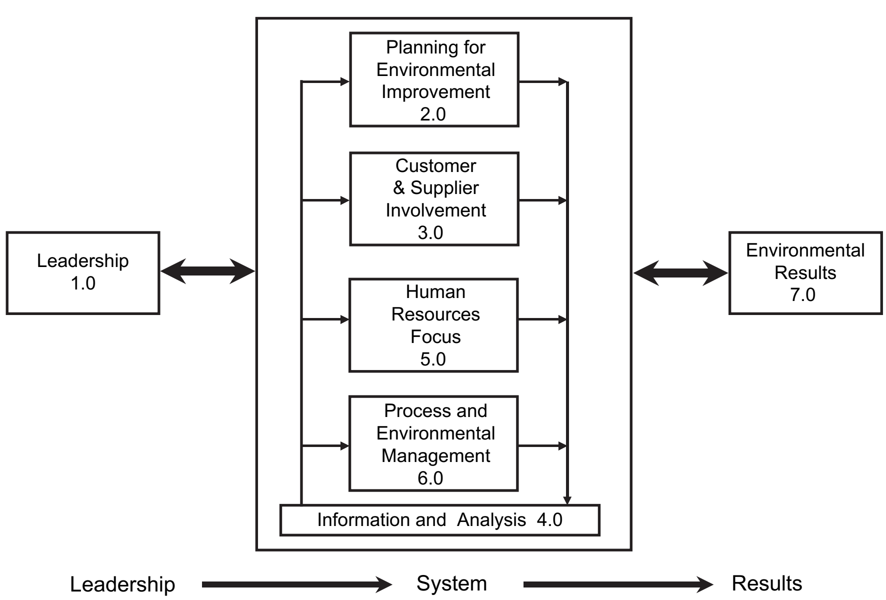

Fig. 1. Relationships for the environmental performance model.

the leadership category has been changed from a focus on overall business performance excellence to a specific focus on environmental performance, and the leadership items were revised to reflect the need for an environmental vision that is understood by all employees.

In addition, the leadership program elements were modified to address the communication of the environmental vision, employee involvement in environmental programs, compliance with regulations, and management reviews of environmental programs. The environmental performance model closely resembles the Baldrige Excellence model except that it focuses specifically on the environmental health and safety results of a business [43]. The comparison of the Baldrige Business Model and its environmental derivative is presented in Appendix A.

Fig. 2 depicts the environmental performance model, expressed using LISREL terminology. As shown in Fig. 2, the key parameters in the environmental performance model are the ξs (Ksis), which are the latent independent variables, and the Xs, which are the observed variables for these independent variables. The ηs (Etas) are the latent dependent variables, and the Ys are the indicators for these dependent variables.

5. Research methods

To validate the environmental performance improvement model for SMEs, the authors surveyed 458 small manufacturers. This section briefly describes the development of the questionnaire, rationale for selection of industry categories, selection of companies based on size, sample size, the pilot project, and data collection and analysis.

5.1. Environmental performance model questionnaire

A questionnaire was developed to test the previously defined elements of the environmental performance model, which is based on the 2001 Baldrige Performance Excellence Criteria [41]. This survey instrument was initially developed based on a review of the literature on Baldrige Performance Criteria model validation and includes questions on the seven major categories of the environmental performance model. Each category and item or sub-category was measured using a seven-point Likert scale, selected because it provides optimal reliability [44–46]. The seven-point scale also provides sufficient choices to supply maximum contrast. Respondents were asked to indicate their perception of each measurement item for the seven categories of the environmental excellence model.

Elements of the National Academy of Sciences (NAS) Environmental Learning Curve were utilized to create the environmental results scale [47]. Fig. 3 illustrates this NAS curve.

The NAS continuum was designed to illustrate environmental progress over time. The NAS Environmental Management Learning Curve is equally appropriate for measuring the maturity of the environmental programs of individual companies. The scale that was created for measuring environmental performance consisted of the following categories: compliance with regulations; implementation of pollution prevention programs; environmentally responsible products and processes; improved environmental performance of suppliers; and improved employee satisfaction, health and safety. These measurement categories are also consistent with the Baldrige Criteria core value of public responsibility and citizenship, which supports environmental results categories (resource

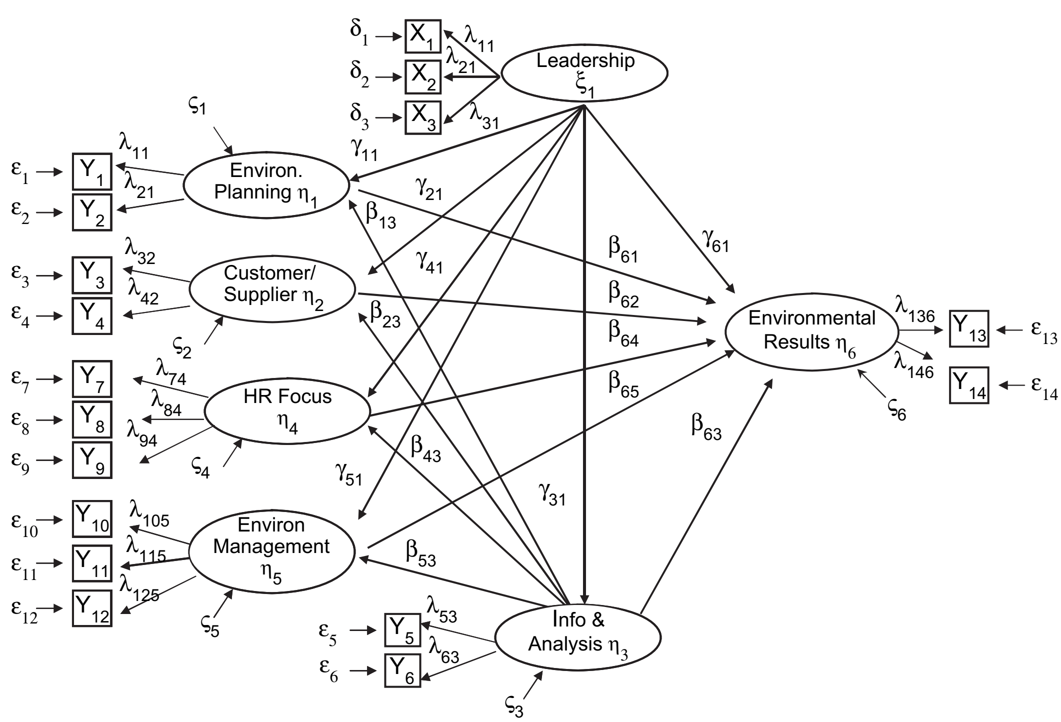

Fig. 2. Full structural equation model in LISREL notation.

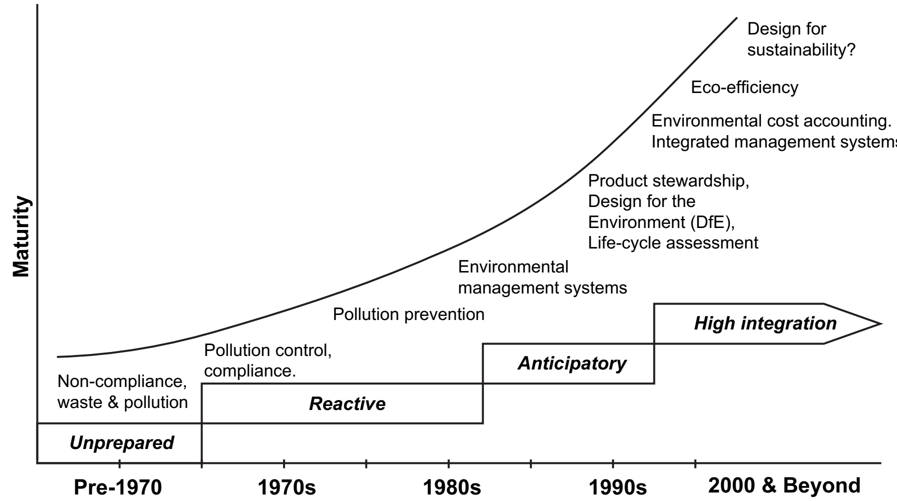

Fig. 3. Industry's environmental design and management learning curve.

conservation, waste reduction, life-cycle philosophy, design for the environment and "beyond compliance" practices). The measurement categories also incorporate the systems approach, which is consistent with the Baldrige core value of systems perspective. The continuum also provides a framework for assessing a company's environmental performance.

5.2. Company sample population

For this study, industry categories were selected using the 1999 Environmental Protection Agency Toxic Release Inventory Data, released to the public by EPA on April 11, 2001 to identify appropriate SIC[1] codes.

The Toxics Release Inventory (TRI), a publicly available EPA database, contains information on specific toxic chemical releases and waste management activities reported annually by covered industry groups and federal facilities. This inventory, established under the Emergency Planning and Community Right-to-Know Act of 1986 (EPCRA), requires facilities to use their best available data to calculate their releases and waste management estimates. If facilities do not have actual monitoring data, submitted values can be derived from various estimation techniques.

Statistics from the reporting year 1999 were the most recent TRI data available when the research was initiated. Facilities reporting to TRI were required to submit 1999 data to EPA by July 2000. The TRI data are available through the EPA web site (http://www.epa.gov/tri/).

5.3. Sample size

Structural equation modeling requires that sample sizes be greater than 200. With 1968 small fabricated metal manufacturers (SIC[5] 34) available for the survey, it was anticipated that modeling size requirements would be easily met. A second population of 1272 plastics manufacturers (SIC 30) was also surveyed. Data from fabricated metal manufacturers (SIC 34) and plastics manufacturers (SIC 30) were analyzed together.

5.4. Main survey data collection

Representatives from the University of Wisconsin Survey Center conducted the phone questionnaire.

5.5. Data analysis using structural equation modeling

The general rule for SEM is that five to 10 observations are required for each model parameter estimated [4]. Hair et al. [4] recommends a sample size of 100–200 when using the maximum likelihood estimation (MLE) procedure (1998). This project used 458 samples, which were adequate for using structural equation modeling.

6. Results

Model valuation criteria, participation rates, and model validation results are presented in this section.

6.1. Fit statistics and cutoff criteria

The two most common ways of evaluating model fit are use of the χ^2 goodness-of-fit statistic and the use of other absolute or relative fit indices [48]. The χ^2 goodness-of-fit statistic assesses the magnitude of the difference between the sample and fitted covariance matrices. This statistic is the product of the sample size (N) minus 1 and the minimum fitting function ($F_{\min}$) (denoted as $T = (N-1)F_{\min}$). The t-statistic (also called χ^2) has an asymptotic (large sample) χ^2 distribution under an assumed distribution and the hypothesized model for the population covariance matrix [48]. Suggested cutoffs for χ^2/df range from <5 to <2 depending on the investigator. Byrne [49], for example, suggests $\chi^2/\text{df} < 2$. Kelloway [50] suggests a range between 2 and 5, with a value <2 indicating over-fitting.

[5] SIC, the Standard Industrial Classification (SIC) Code, was developed by the U.S. government to categorize companies based on common manufacturing processes and technologies.

Another way to evaluate the fit of a model is to use fit indices that have been offered to supplement the χ^2 test. Fit indices range from 0 to 1, with values closer to 1 indicating very good fit. Hu and Bentler [48] recommend MLE-based fit indices and also suggest a two-index presentation strategy with, among others, the MLE-based Tucker–Lewis Index (TLI), comparative fit index (CFI), and Gamma hat or root mean square error of approximation (RMSEA). The χ^2 test and CFI were used in this study. In addition, because the data are non-normal, the Satorra and Bentler [51] χ^2 and the Incremental Fit Index (IFI) [52] fit statistics were used.

The fit indices should have values of 0.95 or greater and RMSEA should range between 0.02 and 0.1, with <0.05 indicating a good fit, <0.08 indicating a reasonable fit, <0.10 indicating a mediocre fit and <0.02 indicating over-fitting [53,54]. Fit indices applicable to the data will be discussed in Section 6.3.

6.2. Survey participation

Participation statistics are summarized in Table 1. Participation rates were 45% for fabricated metal manufacturers (SIC 34) and 33% for plastics manufacturers (SIC 30).

6.3. Data analysis

A two-step process was used to test the environmental performance model [55]. The first step assessed the measurement model. In the second step, causal relationships were introduced and the full structural equation model was evaluated. Averaging the scores for a scale was the method used to create a single value for each of the 16 observed variables (senior leadership direction, environmental performance review, public responsibility and citizenship, environmental strategy development, environmental strategy deployment, customer environmental requirements, customer satisfaction with environmental performance, measurement and analysis of environmental performance, environmental information management, work systems, employee environmental education, employee well-being, environmentally responsible products, environmental management process, environmental support process and environmental results) in the environmental performance model [6]. In structural equation modeling, it is preferable to have two indicators for each construct. All of the latent variables in the environmental performance model had multiple indicators except "results." Through factor analysis, the "results" questions were reduced to two factors. These two factors were used for structural equation modeling.

Table 1
Fabricated metal manufacturers and plastics manufacturers

Categories	Fabricated metal manufacturers	Plastics manufacturers
Companies in Dun & Bradstreet database	1968	1272
Pilot project companies	27	16
Ineligible companies[a]	36	33
Net eligible companies	1905	1223
Participating companies	308	150
Nonrespondents	379	338
Not surveyed	1218	772
Response rate	44.83%	33.25%

[a] Ineligible companies: out of business, change in SIC code, change in company size, etc.

Table 2
Fit statistics for environmental performance measurement model (SMEs)

		Absolute fit measures				Relative fit measures	
	Sample size	χ^2	df	Satorra–Bentler χ^2	RMSEA	CFI	IFI
Small and medium-sized manufacturers	458	452	98	346	0.050	0.99	0.99

Data for small fabricated metal manufacturers (SIC 34), and small plastics manufacturers (SIC 30) were analyzed. The measurement model and then the full structural model were tested using each data set. Maximum likelihood (ML) and generalized least squares (GLS) estimators are based on use of normal data, and if the data are not normal, the χ^2 goodness-of-fit test using these estimators can reject too many true models and produce biased parameter estimates [52]. However, Olsson et al. [56] demonstrated that the ML estimation method is sufficiently robust to perform well even when data are non-normal and the model is misspecified. Therefore, the robust maximum likelihood (RML) method was used to estimate parameters for this model and fit indices that are less sensitive to non-normal data (Satorra–Bentler χ^2, CFI and IFI) were used to interpret the model fit.

6.4. Small manufacturers (SMEs)

The measurement model was analyzed using data from 458 completed surveys. Results of the analysis, which are summarized in Table 2, indicate a reasonable data fit, with $\chi^2/\text{df} = 3.53$, RMSEA $= 0.050$ and CFI $= 0.99$.

The full structural model was then tested and again the results, which are summarized in Table 3, indicate a reasonable model fit with $\chi^2/\text{df} = 2.33$, RMSEA $= 0.054$ and CFI $= 0.98$.

The fit indices confirm the primary hypothesis (H_1) that the overall environmental performance model is valid and that leadership (1.0) drives the system (2.0–6.0), and the system in turn predicts environmental results. Fig. 4 illustrates the fitted environmental performance model.

The relationships between the internal components (i.e., the relationships between leadership and planning, leadership and

Table 3
Fit statistics for validating the full environmental performance model (SMEs)

		Absolute fit measures				Relative fit measures	
	Sample size	χ^2	df	Satorra–Bentler χ^2	RMSEA	CFI	IFI
Small and medium-sized manufacturers	458	504	104	242	0.054	0.98	0.98

customer support, leadership and human resources focus, environmental management systems and environmental results, information and analysis and environmental results) are summarized in Table 4.

Consistent with the other data sets, the overall model fit is reasonable, but the paths to environmental results are not statistically significant. The relationships between leadership and information and analysis, leadership and planning for continuous environmental improvement and leadership and human resources focus were significant. The relationships between information and analysis and planning for continuous environmental improvement, information and analysis and customer and supplier involvement, information and analysis and human resource focus, and information and analysis and process and environmental management were also significant.

7. Discussion and conclusion

The literature shows that SMEs play a potentially significant role in environmental protection. Research has confirmed that SMEs need assistance in the form of models, tools and partnerships in order to improve their environmental performance. The authors propose that structural equation modeling has value for validating SME-focused environmental performance models.

This research supports the hypothesis that structural equation modeling can be useful in validating environmental performance models for SMEs. The authors also believe that the SEM technique could be used to further refine models by showing where problems exist in the model structure. In this project, the authors developed a performance-based environmental improvement model for SMEs in the plastics and fabricated metal manufacturers sectors using the Baldrige Criteria. This study is supported by other research indicating that total quality management improves efforts at pollution reduction [57] and by studies that indicate that environmental management systems improve environmental performance [58,59]. The authors conclude that the overall environmental performance model for SMEs is valid, but that not all of the paths in the model can be shown to be statistically significant. The secondary paths provide insights into the challenges that are faced while improving environmental performance in SMEs.

SEM allows the researcher to test the model on large and potentially different industry segments. The authors used SEM to perform confirmatory factor analysis. SEM is also useful in model modification and refinement based on data. This is called exploratory factor analysis. SEM can be used to determine if an overall environmental performance model should be adjusted or if the model adjustments are needed to fit to various business sectors.

The evaluation process showed that the SEM method can be used to identify problems with individual elements of the model. This research identifies potential problems with how SMEs define and understand the term ‘‘environmental results’’. Although an improved environmental results scale might have yielded more significant correlations between the individual systems components and environmental results, this research results question whether SMEs understand the

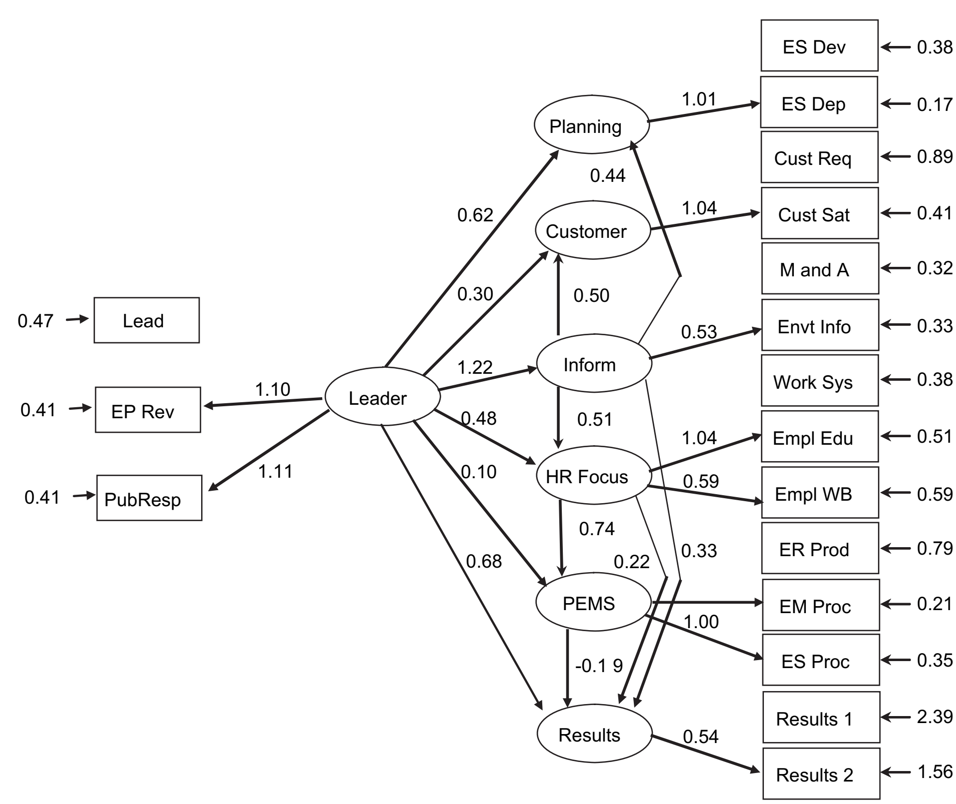

Fig. 4. Fitted environmental performance model for SMEs.

Table 4
Path hypothesis confirmation using SME data

Model hypotheses		Results
H_2: leadership (1.0) has a direct, positive influence on environmental results (7.0).	Coefficient	0.68
	t-Statistic	$t = -0.38$
	Significant?	*Not significant*
H_3: leadership (1.0) has a positive influence on information and analysis (4.0).	Coefficient	1.22
	t-Statistic	$t = 21.64$
	Significant?	*Significant*
H_4: leadership (1.0) has a positive influence on planning for continuous environmental improvement (2.0).	Coefficient	0.62
	t-Statistic	$t = 6.17$
	Significant?	*Significant*
H_5: leadership (1.0) has a positive influence on customer and supplier involvement (3.0).	Coefficient	0.30
	t-Statistic	$t = 1.92$
	Significant?	*Not significant*
H_6: leadership (1.0) has a positive influence on human resource focus (5.0).	Coefficient	0.48
	t-Statistic	$t = 3.53$
	Significant?	*Significant*
H_7: leadership (1.0) has a positive influence on process and environmental management (6.0).	Coefficient	0.10
	t-Statistic	$t = 0.95$
	Significant?	*Not significant*
H_8: information and analysis (4.0) have a positive influence on planning for continuous environmental improvement (2.0).	Coefficient	0.44
	t-Statistic	$t = 5.96$
	Significant?	*Significant*
H_9: information and analysis (4.0) have a positive influence on customer and supplier involvement (3.0).	Coefficient	0.00
	t-Statistic	$t = 4.27$
	Significant?	*Significant*
H_{10}: information and analysis (4.0) have a positive influence on human resource focus (5.0).	Coefficient	0.00
	t-Statistic	$t = 5.37$
	Significant?	*Significant*
H_{11}: information and analysis (4.0) have a positive influence on process and environmental management (6.0).	Coefficient	0.00
	t-Statistic	$t = 8.94$
	Significant?	*Significant*
H_{12}: information and analysis (4.0) have a positive influence on environmental results (7.0).	Coefficient	0.33
	t-Statistic	$t = 0.13$
	Significant?	*Not significant*
H_{13}: planning for continuous environmental improvement (2.0) has a positive influence on environmental results (7.0).	Coefficient	−0.51
	t-Statistic	$t = -0.23$
	Significant?	*Not significant*
H_{14}: customer and supplier involvement (3.0) has a positive influence on environmental results (7.0).	Coefficient	0.05
	t-Statistic	$t = -0.60$
	Significant?	*Not significant*
H_{15}: human resource focus (5.0) has a positive influence on environmental results (7.0).	Coefficient	0.22
	t-Statistic	$t = -0.24$
	Significant?	*Not significant*
H_{16}: process and environmental management (6.0) has a positive influence on environmental results.	Coefficient	−0.19
	t-Statistic	$t = -0.20$
	Significant?	*Not significant*

environmental implications of their operations. Curkovic [57] has confirmed the link between the Baldrige Criteria and environmentally responsible manufacturing (ERM). ERM was designed as an economically driven, system-wide and integrated approach to reducing or eliminating all pollution in the design, manufacture, use and/or disposal of products and materials. Pollution prevention, a narrow definition of environmental results, was used as the output portion of this model. During this research, we used a broad definition of results that included compliance with regulations; implementation of pollution prevention programs; designing environmentally responsible products and processes; improving environmental performance of suppliers; and increasing employee satisfaction, health and safety. While these are important indicators of proactive environmental performance, they are probably too advanced for SMEs, which typically are closer to the beginning of the Environmental Management Learning Curve. Recent research by MacLean shows that even among large companies, there is little agreement on the definition of superior environmental performance [60]. Our research suggests that it may be necessary to reach a broader consensus on a definition of environmental results as the first step in building an environmental performance model for SMEs.

Taking tools designed to improve the environmental performance of large organizations and "down-sizing" them for SMEs may not be appropriate. Research indicates that SMEs need tools designed specifically for their organizational needs. The authors believe that structural equation modeling is an appropriate statistical tool validating performance models developed for small manufacturers. This research also shows that care is required in defining all of the elements of an environmental performance model designed for SMEs.

Appendix A. Comparison of the environmental model and Baldrige Criteria

Environmental performance model (and items)	Baldrige Excellence Criteria (and items)
Leadership	Leadership
Senior leadership direction	Organizational leadership
Environmental performance and public responsibility	Public responsibility and citizenship
Planning for continuous environmental improvement	Strategic planning
Environmental strategy development	Strategy development
Environmental strategy deployment	Strategy deployment
Customer and supplier involvement	Customer and market focus
Customer and market environmental requirements	Customer and market knowledge
Customer relationships and satisfaction with environmental performance	Customer relationships and satisfaction
Information and analysis	Information and analysis
Measurement and analysis of environmental performance	Measurement and analysis of organizational performance
Environmental information management	Information management
Human resource focus	Human resource focus
Work systems	Work systems
Employee EHS education, training, and development	Employee education, training, and development
Employee well-being (safety) and satisfaction	Employee well-being and satisfaction
Process and environmental management	Process management
Environmentally responsible product and service processes	Product and service processes
Environmental management processes	Business processes
Environmental support processes	Support processes
Environmental results	Business results
	Customer-focused results
	Financial and market results
Human resource results	Human resources results
Environmental effectiveness results	Organizational effectiveness results

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