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Full Length Research Paper

Managing multinational sustainable development in the European Union based on the DPSIR framework

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With 27 member states, the European Union has a population of nearly half a billion, making its sustainable development both important and multinational. Though the practicality of the Driving forces-Pressure-State-Impact-Response (DPSIR) framework is widely recognized in Europe, it has never been applied to choose sustainability indicators for the European Union. This study focused on using the DPSIR framework to establish a set of sustainable development indicators clearly displaying their casual links in the European region. The DPSIR framework was used to select 28 indicators, as well as to collect corresponding data for 27 member states between 2005 and 2006. After applying the partial-least-squares (PLS) technology to determine how each construct was related, experimental results proved all of the causal links other than the effects of 'response' on 'driving forces', 'pressure' and 'state'. This study also suggested some other environment-management methods related to the DPSIR framework for European authorities, together with a longitudinal assessment of the proposed model.

Key words: Sustainable development, DPSIR framework, European Union, PLS technology.

INTRODUCTION

Sustainable development is important owing to the irreversible nature of ecological destruction. To improve the life of their people, governments all over the world have focused on economic growth. Inevitably, economic development influences ecological system and social system due to their interrelationships (Giddings et al., 2002; du Plessis, 2000; Barton, 2000; ICLEI, 1996). Specifically, a tradeoff appears to exist. Therefore, reconciling the dilemma between economic development and the other two sectors is essential.

The Driving forces- Pressure- State- Impact- Response (DPSIR) framework is the latest version of indicator frameworks developed by the Organization for Economic Co-operation and Development (OCED) (EEA, 1999). This framework has been widely applied to identify cause-and-effect relationships related to sustainability (Wei et al., 2007; Gobin et al., 2004; Yoon and Lee, 2003). The European Environment Agency (EEA) also made DPSIR the main model for assessments of environmental sustainability and related activities (EEA, 1995).

"The European Union (EU), an economic and political union of 27 member states", is the world's largest trading power (Europa, 2009a). The EU follows spatial development policies, known as the European Spatial Development Perspective (ESPD), to ensure balanced and sustainable development within its territory (Europa, 2009b). A set of indicators, reflecting the seven key chal-

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lenges: climate change and clean energy, sustainable transport, sustainable consumption and production, conservation and management of natural resources, public health, social inclusion, demography and migration and global poverty and sustainable development challenges, have been devised to monitor the EU Sustainable Development Strategy (SDS) (Eurostat, 2009). However, the selection of these indicators did not consider the DPSIR framework, leading to ignorance regarding the interactions among those categories and subsequent failure to locate the real causes of the upcoming challenges.

This study demonstrates that the DPSIR framework can be applied to implement the idea of building up a set of sustainable development indicators based on cause-and-effect relationships in the European Union. The rest of this paper is organized as follows: first, an introduction, after which a review on previous literature on sustainable development and the DPSIR framework is discussed. Next, an assessment model and associated hypotheses, as well as introducing methodology and data selection criteria are presented. The collected data is then analyzed, after which the assessment model is tested via partial-least-square (PLS) technology. Conclusions are finally drawn, along with managerial implications for policy makers.

LITERATURE REVIEW

To further understand sustainable development in the EU, the literature review begins with sustainable development researches from global issues to local problems, then introduces sustainable development indicators and the DPSIR framework and finally presents applications of the DPSIR framework.

Various analytical levels of sustainable development research

Different levels of analysis can be applied to indicator design in relation to sustainable development: international level, regional level, national level and local or project level (Segnestam, 2002). Various studies have examined the international level (Moran et al., 2008; Wilson et al., 2007; Zoeteman, 2000). For example, Zoeteman (2000) applied various indicators to form three indexes and then aggregated them to produce a comprehensive sustainability index. Calculating the sustainability indexes of 24 nations, identified Sweden as the most sustainable and Sierra Leone as the least sustainable.

"Regarding the regional sustainability, numerous related" papers have recently been published (Simon et al, 2009; Golusin et al., 2009; Patlitzianas et al., 2007; Distaso, 2007). Golusin et al. (2009) created four subsystems including 38 indicators for comparing the current sustainability of 11 countries in Southeastern Europe. Golusin observed that the lower ecological indicator values (such as 'pollution of air') in France and Germany reflected their high scores in economic indicators (such as 'energy'). However, Golusin also realized that the ecological situation of these two countries was not that bad and concluded a possible decoupling between economic development and ecological potential.

Other researches have focused on the national level (Chen et al., 2009; Nourry, 2008; Amajirionwu et al., 2008). For example, Nourry (2008) employed eight different measures to evaluate sustainability in France between 1990 and 2000. Their work stressed that the analysis of various indicators is essential for accurately assessing sustainable development.

Numerous investigations have examined sustainable development at the local and project levels (Erol et al., 2009; Zhang et al., 2009; Wei et al., 2007; Lee et al., 2007; Yoon and Lee, 2003; Walmsley, 2002). For example, Lee et al. (2007) selected 51 indicators which were then classified into economic, social, environmental and institutional dimensions to identify sustainability trends for Taipei from 1994 to 2004. Moreover, Wei et al. (2007) proposed a DPSIR framework for identifying a group of indicators for assessing the sustainable development of the panda natural heritage site in Sichuan, China.

In comparison with the international level and regional level, developing indicators at the national, local and project levels is more practical and more action-oriented. Additionally, the casual links are easily identifiable. On the other hand, at the international and regional levels, the involvement of different countries requires consensus on both the issues and the indicator selection (Segnestam, 2002). These two levels, thus, are considered more political than practical. Nevertheless, nowadays, close interactions between neighboring countries are increasingly difficult to ignore. The EU member states comprise an economic and political union that shares the European territory. The study of sustainable development within the EU is more meaningful than political.

EU sustainable development indicators

Monitoring, measuring and reporting environmental and economic changes can provide experts on sustainable development with timely or inferable information. Indicators can also play this role. An indicator is a variable describing a particular characteristic of the system state, generally via observed or estimated data (Mayer, 2008). Based on their EEA typology, environmental indicators can be classified into four different types (Gabrielsen and Bosch, 2003; Smeets and Weterings, 1999), as follows:

1) Descriptive indicators: The actual situation regarding key environmental issues and living beings, including climate change, acidification and toxic contamination and waste; 2) Performance indicators: Descriptive indicators associated with target values. For instance, an indicator compares the pollution removal rate for nitrogen and

Table 1. The sustainable development indicators of European Union.

Theme	Sub-theme
Socio-Economic Development	Economic Development
	Innovation, Competitiveness and Eco-Efficiency
	Employment
Sustainable Consumption and Production	Resource Use and Waste
	Consumption Patterns
	Production Patterns
Social Inclusion	Monetary Poverty and Living Conditions
	Access to Labor Market
	Education
Demographic Changes	Demography
	Old-Age Income Adequacy
	Public Finance Sustainability
Public Health	Health and Health Inequalities
	Determinants of Health
Climate Change and Energy	Climate Change
	Energy
Sustainable Transport	Transport and Mobility
	Transport Impacts
Natural Resources	Biodiversity
	Fresh Water Resources
	Marine Ecosystems
	Land Use
Global Partnership	Globalization of Trade
	Financing for Sustainable Development
	Global Resource Management
Good Governance	Policy Coherence and Effectiveness
	Openness and Participation
	Economic Instruments

Source: http://epp.eurostat.ec.europa.eu/portal/page/portal/sdi/introduction.

phosphorus during 2000with national targets; 3) Efficiency indicators: The relationship between separate elements of the causal chain, such as the level of emissions and waste generated per unit of GDP; 4) Policy effectiveness indicators: The actual change of environmental variables as a result of policy efforts, such as the reduction of sulphur dioxide emissions because of efficiency improvements; 5) Total welfare indicators: Indicators including sustainability and human welfare, for example the Index of Sustainable Economic Welfare (ISEW).

In 1996, the United Nations Commission on Sustainable Development (UNCSD) proposed a list of 134 indicators (United Nations, 1996). Subsequently, in 1998, Eurostat hosted a meeting with the members of the European Union to examine the UN list of indicators, with the aim of advancing the development and application of Sustainable Development Indicators (SDIs) across EU member states (Eurostat, 2007). The European Council in Göteborg adopted the first EU Sustainable Development Strategy (SDS) in 2001. According to SDS, the European Commission is supposed to devise indicators specifically to manage sustainable progress regarding all those environmental issues.

In 2005, the European Commission endorsed an initial set of 155 sustainable development indicators and then further reviewed this set in 2007. SDIs are used to monitor the SDS in the EU at two year intervals (Eurostat, 2009). SDIs are based on ten themes which follow a general gradient from economic, to social and finally to environmental and institutional dimensions. Table 1 lists the themes and sub-themes of the indicators.

DPSIR framework

An indicator framework constructs the indicators and clarifies their interrelationships. The DPSIR framework assumes that indicators of driving forces, pressure, state, effect, and response are inter-related (Yoon and Lee, 2003). Environmental indicators developed according to the DPSIR framework include driving forces, pressure and state, impact and response indicators, based on the type of information provided.

The five categories (DPSIR) are defined as follows: 1) Driving forces: Human influences and activities that positively or negatively impact the environment (for example, total R & D expenditure); 2) Pressure: Human use of natural resources and land and production of waste and emissions (such as, greenhouse gas emissions); 3) State: Currently measured environmental quality and how it is influenced by environmental pressures (such as, water quality); 4) Impact: The negative effects of environmental changes on ecosystems (such as, loss of terrestrial biodiversity); 5) Response: The societal responses by government, organizations, the community and so on (for example, legislative initiatives to protect native vegetation).

Applications of the DPSIR framework

The DPSIR framework has been extensively applied in environmental studies on both macro (national, regional, global) and micro (local) scales (Amajirionwu et al., 2008; Wei et al., 2007; Karageorgis et al., 2006; Fistanic, 2006; Odermatt, 2004; Yoon and Lee, 2003; Walmsley, 2002). Regarding macro scales, Yoon and Lee (2003) analyzed 57 of 80 South Korean cities via the DPSIR framework. Yoon and Lee (2003) found that most indicators in 'driving forces', 'pressure' and 'state' differed significantly among large, medium and small cities and thus concluded that the DPSIR model permitted organized and systematic analysis. Regarding micro scales, Fistanic (2006) em-ployed the DPSIR framework to examine factors related to environmental destruction in the Pantan area of Croatia. The outcome of Fistanic's study demonstrated that the DPSIR framework is an appropriate method of developing sustainable development strategy for the area.

Despite its extensive use in the research of environmental problems, the DPSIR framework remains subject to certain criticisms, including lacking extensive statistical data, applying linear unilateral casual links in a complex environmental context and simplifying ecosystem range and causalities (Bell and Etherington, 2009; Rekolainen et al., 2003). Nevertheless, to date, the DPSIR framework is globally recognized as a means of identifying meaningful indicators of cause-and-effect relationships (Bell and Etherington, 2009; Carr et al., 2007; Walmsley, 2002; Smeets and Weterings, 1999).

"EEA has promoted European knowledge of the DPSIR framework". The report, a General Strategy for Integrated Environmental Assessment at EEA, recognized DPSIR as the main framework for assessing environmental challenges. The framework has evolved from a tool for describing natural ecosystems under stress to a framework for describing human-environment interactions and related information flows (Gabrielsen and Bosch, 2003).

METHODOLOGY

This study attempts to establish a DPSIR framework to illustrate the cause-and-effect relationships associated with environmental sustainability in the European Union. Furthermore, this study applies partial-least-squares (PLS) technology to test the casual links for each category. This process involves a four-part procedure: the first step is to establish an assessment model. Next, seven hypotheses are proposed by referring to this model. Subsequently, the partial-least-squares (PLS) technology is introduced. Finally, detailed information is presented regarding indicator selection rules and data collection.

Assessment model

This study proposes an assessment model for evaluating sustainable development in the EU using the DPSIR framework. Figure 1 presents the assessment model developed in this work.

Hypotheses

Figure 1 shows the interrelations among the five categories: driving forces, pressure, state, impact, and response. Seven hypotheses are thus proposed, as follows:

H1: Environmental pressure increases with economic growth;
H2: Environmental conditions deteriorate with an increasing environmental pressure;
H3: Ecosystems suffer as the environmental state worsens;
H4: Ecosystem damage evokes strong societal responses;
H5: A strong societal response reduces the economic drivers of ecosystem damage;
H6: A strong societal response reduces environmental pressures;
H7: A strong societal response improves the environmental state.

PLS Technology

This study applies partial-least-squares (PLS) technology. PLS technology involves a combination of principal components analysis, path analysis and regression. PLS is especially suitable for exploratory studies and model testing (Gefen et al., 2000; Chin, 1998b). PLS offers a couple of notable advantages, together with minimal requirements regarding sample size and residual distributions (Gefen et al., 2000; Chin, 1998a, 1998b).

"PLS technology develops via two stages". In the first stage, multi-item variable construct validity and reliability is assessed prior to estimating the final PLS structural model. The convergent validity for the reflective constructs is confirmed, as the average variance extracted (AVE) exceeds the guideline of 0.5 (Fornell and Larcker, 1981). All the reflective constructs had component reliability exceeding the recommended level of 0.70 (Nunnally, 1978) indicating internal consistency. The second stage assesses the refined structural model. In the structural framework, a path represents each hypothesis. Path coefficients resemble the standardized beta weights in regression analysis. The corresponding t-values are determined using jack-knifing. Good structural model fit exists given reasonably high explanatory power (measured by R-square) and statistically significant t-values.

This study investigates the cause-and-effect relationships among the five constructs within the DPSIR framework, where each indicator contains 54 raw data from 27 member states for two years.

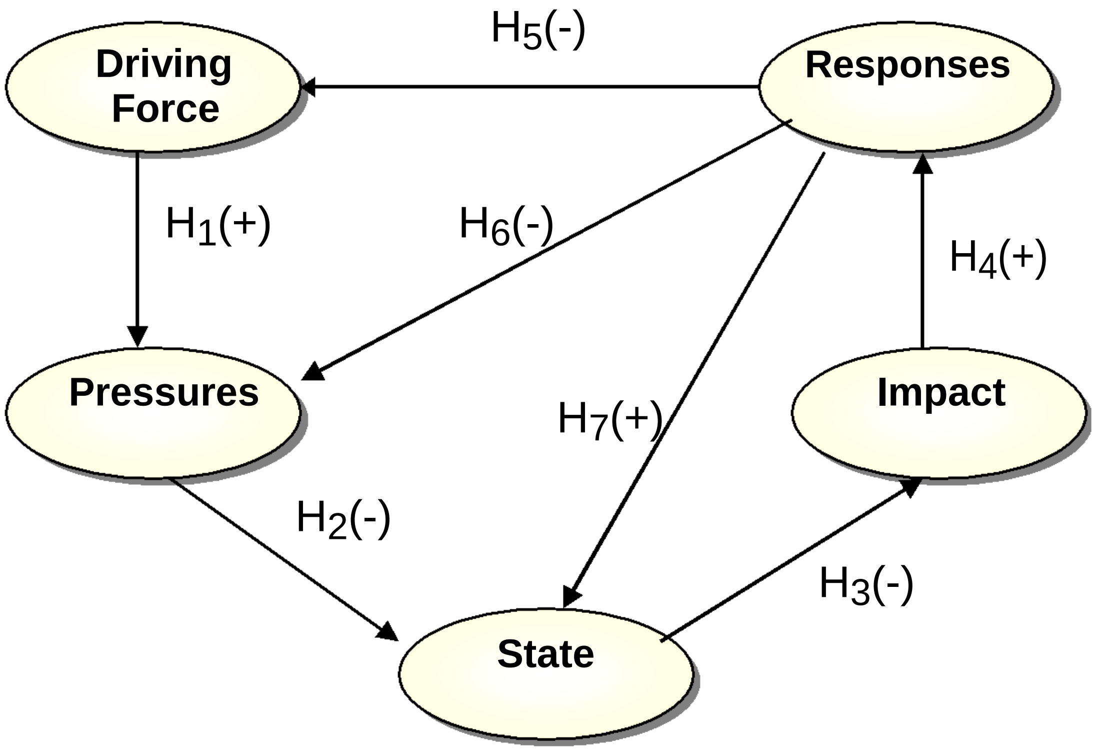

Figure 1. The assessment model of “sustainable development of EU territory” based on DPSIR.

Indicator selection and data collection

To select appropriate indicators for this investigation, a couple of criteria must be met: 1) Environmental relatedness: This study explores ecosystem sustainability in the EU. Therefore, this study ignores certain indicators, such as ‘life-long learning’, that have a relatively weak relationship with the health of the environment and living beings. 2) Description orientation: This study only selects descriptive indicators, such as ‘total investment’ rather than other types of indicators, such as ‘energy intensity of the economy’.

To conform to the principles above, this investigation adopted 28 indicators from among the EU Sustainable Development Indicators (Eurostat, 2009) and applied them to data for the 27 EU member states for 2005 and 2006. Based on their positions on the casual chain, the indicators were designated into different categories of the DPSIR framework. The values of the selected indicators were standardized to achieve indicator homogeneity. Table 2 lists those selected indicators.

Empirical results

This study covers both path analysis and hypothesis testing. The structural model was assessed using PLS Graph version 3.00. Figure 2 illustrates all the path coefficients and R-squares for the research model.

The results of hypotheses testing are listed as follows: 1) Examining the influence of ‘driving forces’ on ‘pressure’ reveals that ‘driving forces’ positively influences ‘pressure’ (t value = 10.695, p < 0.001), supporting H1; 2) H2 is also supported: ‘pressure’ significantly impacts ‘state’ (t value = -0.456, p < 0.05), meaning the ‘state’ deteriorates with increasing pressure; 3) The path coefficient of ‘state’ significantly predicts ‘impact’ (t value = -0.437, p < 0.01). This result strongly suggests that the impact on ecosystems increases with deteriorating environmental state. H3 thus is supported; 4) H4 is supported. ‘Impact’ strongly and positively affects ‘response’ (t value = 5.213, p < 0.001), indicating that a stronger ‘impact’ on ecosystem evokes a stronger societal ‘response’; 5) H5 is not supported. ‘Response’ positively and significantly affects ‘driving forces’ (t value = 12.614, p < 0.001) but the effect runs opposite to the expected direction; 6) H6 is not supported since the path for ‘response’ to ‘pressure’ is not significant (t value = -0.159, p = 0.583); 7) H7 is not supported. ‘Response’ negatively and significantly affect ‘state’ (t value = -1.842, p < 0.05) but the effect runs against the expected direction.

DISCUSSION

This study examines cause-and-effect relationships in the sustainable development of the European Union by adopting a DPSIR framework and PLS technology. Empirical analysis demonstrates that economic growth creates environmental pressure, which in turn leads to a deteriorating environmental situation, ecological impacts, and ultimately a social response. However, the societal responses do not influence driving forces, relieve pressure, or improve the state. Several potential obstacles exist to these findings: first, while weighing the importance between the economic development and environmental protection, most countries still always prioritize economic development (Giddings et al., 2002). Furthermore, large international enterprises also strongly

Table 2. A List of selected indicators from EU SDS.

Indicators	Descriptions	Measure
Driving force		
Total investment	Total gross fixed capital formation (GFCF) expressed as a percentage of GDP, for the public and private sectors	% of GDP
Total R&D expenditure	the percentage share of GERD (Gross domestic expenditure on R&D) in GDP	% of GDP
Total employment rate	Dividing the number of persons aged 15 to 64 in employment by the total population of the same age group	%
Final energy consumption	The sum of the energy supplied to the final consumer's door for all energy use	1000 toe
Consumption of certain foodstuffs per inhabitant	The gross human apparent consumption of some major food items (cereals, meat and fish)	kg per capita
Pressure		
Municipal waste generated	The amount of municipal waste generated	Kg per capital)
Emissions of acidifying substances	Anthropogenic atmospheric emissions of acidifying substances (sulphur dioxide, nitrogen oxides and ammonia)	1000 tonnes
Emissions of ozone precursors	Anthropogenic atmospheric emissions of ozone precursors (nitrogen oxides, carbon monoxide, methane and non-methane volatile organic compounds)	1000 tonnes
Emissions of particulate matter	Anthropogenic atmospheric emissions of primary particles, secondary particulate precursors (sulphur dioxide, nitrogen oxides and ammonia)	1000 tonnes
Greenhouse gas emissions	Greenhouse gas emissions	million tonnes CO^2 equivalent
State		
Urban population exposure to air pollution by particulate matter	The population-weighted annual mean concentration of particulate matter at urban background stations in agglomerations	micrograms per cubic meter
Urban population exposure to air pollution by ozone	The population-weighted yearly sum of maximum daily 8-hour mean ozone concentrations above a threshold (70 micrograms of ozone per m3) at the urban background stations in agglomerations	micrograms per cubic meter
Sufficiency of sites designated under the EU habitats directive	The index of sufficiency of Member States proposals for sites designated under the habitats directive measures the extent to which Sites of Community Importance proposed by the Member States adequately cover the species and habitats listed in Annexes I and II to the habitats directive	%
Built-up areas[i]	Residential land, industrial land , quarries, pits and mines , commercial land , land used by public services, land of mixed use, land used for transport and communications, for technical infrastructure, recreational and other open land	km-sq
Annual fellings as a share of net annual increment[ii]	The ratio of annual fellings to net annual increment	%

Table 2. Contd.

Impact[iii]		
Healthy life years	The number of years that a person at birth is still expected to live in a healthy condition	years
life expectancy at birth	The mean number of years still to be lived by a person at birth	years
Death rate due to chronic diseases	The standardized death rate of certain chronic diseases for persons aged less than 65 years	per 100000 persons
Common bird index[iv]	An aggregated index integrating the population abundance and the diversity of a selection of common bird species associated with specific habitats	index 1990 = 100
Forest trees damaged by defoliation	The percentage of trees on forest and other wooded land in the defoliation classes moderate, severe and dead	%
Response		
Organizations with a registered environmental management system	The number of EMAS-registered organizations and sites	number
Area under organic farming[v]	The share of total utilized agricultural area (UAA) occupied by organic farming (existing organically-farmed areas and areas in process of conversion)	%
Share of renewables in gross inland energy consumption	The percentage share of renewables in gross inland energy consumption	%
Share of biofuels in fuel consumption of transport	The percentage of biofuels, calculated on the basis of energy content, in the petrol and diesel consumption of transport	%
Combined heat and power generation	A technology used to improve energy efficiency through the generation of heat and power in the same plant, generally using a gas turbine with heat recovery	% of gross electricity generation
Implicit tax rate on energy	The ratio between energy tax revenues and final energy consumption calculated for a calendar year	Euros per tonne of oil equivalent
Population connected to urban wastewater treatment with at least secondary treatment	The percentage of the population connected to waste water treatment systems with at least secondary treatment	%
Shares of environmental in total tax revenues	The shares of environmental tax in total tax revenues	%

Source: http://epp.eurostat.ec.europa.eu/portal/page/portal/sdi/introduction
i. There are only data available for 1995, and 2000 in place of the data for 2005 and 2006 respectively.
ii. The data for 2000 substitute the data for 2006 due to availability.
iii. To present the changes, the data for this category are adopted by dividing the data for 2005 and 2006 by the corresponding data for 2000.
iv. The data for 2004 substitute the data for 2006 because of availability.
The data for 2007 substitute the data for 2006 because of availability.

influence policy-making for numerous governments. Hence, social responses generally do not slow economic development for H5. Second, a time lag must exist between policy enforcement and its effects for H5, H6 and H7. The 'state' and 'impact' indicators are fundamental to the problem identification stage, which may cause policy reactions. The next stages of policy response formulation, measure implementation and control

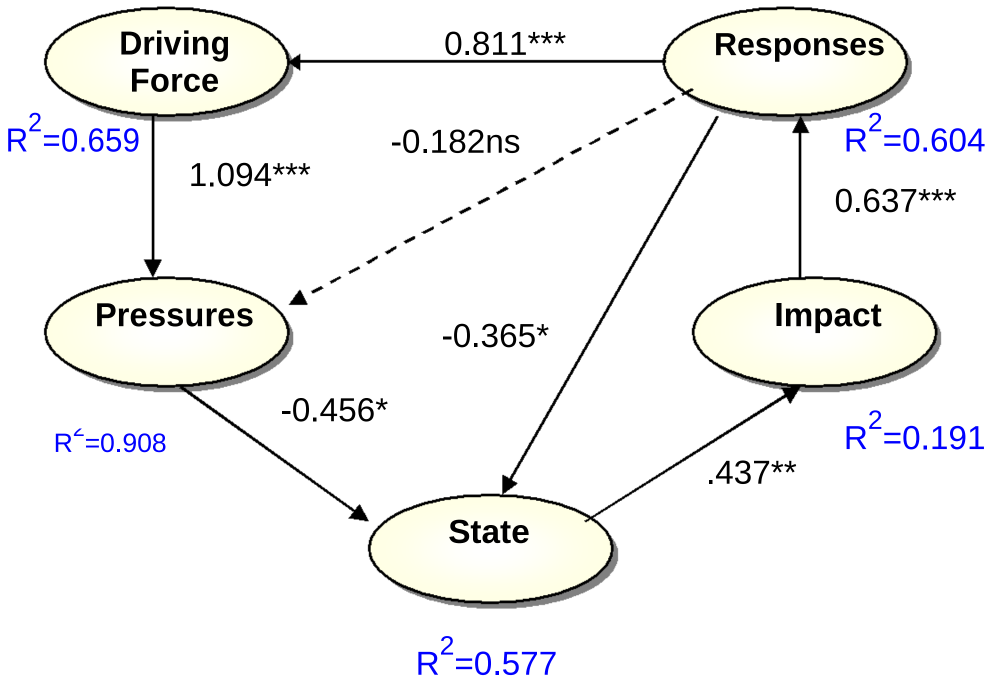

Figure 2. The path coefficients and R-squares of "sustainable development of EU territory" based on DPSIR.

Significance levels:
ns not significance at 0.05;
* significance at 0.05;
** significance at 0.01;
*** significance at 0.001.

which take longer than the previous stage because certain regional or national authorities lack the necessary resources and political influence to alter the drivers of environmental degradation, reduce environmental pressure and improve ecological state (Blaikie, 1985). Third, for H7, some poor environmental states require an extended recovery period and in some cases recovery is impossible. For example, Matthews and Endress (2008) studied 76 compensatory mitigation wetlands re-built between 1991and 2002 in the U.S., and discovered that 67% were not successfully returned to their original ecological state.

Conclusion

This study demonstrates that the DPSIR framework provides a suitable method of establishing a set of meaningful sustainable development indicators and linking their causalities within the European region. Other implications of the study findings are listed below: 1) The European Union should consider the need to establish a set of regional indicators based on the DPSIR framework to provide for the welfare of all member states. Policy-makers thus can easily identify the context of any specific environmental problem and respond correctly to different phrases. For example, to deal with the problem of CO_2 and its contributing to global warming, policy makers must know the corresponding 'driving forces' (e.g. transportation, industrial production, and power generation), 'pressure' (e.g. energy consumption) and 'state' (e.g. high CO_2 concentration). Policy-makers should then be encouraging efficiency improvements in relation to 'driving forces', the widespread application of renewable technologies for the 'pressure', and planting trees for the 'state', which are all adequate options for 'response'. 2) A longitudinal assessment of the model presented in this study is essential to detect the effects of societal responses. All these 'state' and 'impact' indicators require long-term observation over many years to assess the extent to which societal responses are effective. 3) Besides regional level investigations, it is also necessary to trace problem origins down to the country level. For instance, according to the data, Poland, Germany and the Czech Republic are the most heavily industrialized regions in Europe and have strong economic driving forces, but the environmental state of Germany is superior to those of Poland and the Czech Republic. This in-depth exploration provides detailed information not only for supervision but also for guidance and assistance. The EU can respond by infusing Germany's successful experience into these two highly-polluted countries to promote regional sustainability.

REFERENCES

Amajirionwu M, Connaughton N, McCann B, Moles R, Bartlett J, O'Reaan B (2008). Indicators for managing biosolids in Ireland. J. Environ. Manage. 88(4): 1361-1372.

Barton H (2000). Conflicting perceptions of neighbourhood. In Sustainable Communities, Barton H (ed.). Earthscan, London.

Bell S, Etherington L (2009). (Re)Connecting the global and local: Europe's regional seas. J. Law Soc. 36(1): 75-93.

Blaikie P (1985). The political economy of soil erosion in developing countries. Longman, London.

Carr ER, Wingard PM, Yorty SC, Thompson MC, Jensen NK, Roberson J (2007). Applying DPSIR to sustainable development. Inter. J. Sustainable Dev. World Ecol. 14(6): 543–555.

Chen YK, Chen CY, Hsieh TF (2009). Establishment and applied research on environmental sustainability assessment indicators in Taiwan. Environ. Monitor. Assess. 155(1/4): 407–417.

Chin WW (1998a). The partial least squares approach to structural equation modeling. Marcoulides GA (ed.). Modern Methods for Business Research. Lawrence Eribaum Associates, Mahwah, New Jersey.

Chin WW (1998b). Issues and opinion on structural equation modeling. MIS Q. 22(1): 7.

Distaso A (2007). Well-being and/or quality of life in EU countries through a multidimensional index of sustainability. Ecol. Econ. 64(1): 163-180.

du Plessis C (2000). Cities and sustainability: sustaining our cultural heritage. Conference Proceedings, Brandon P, Lombardi P, Perera S (eds). Kandalama, Sri Lanka.

EEA (1995). Europe's Environment: the Dobris Assessment. European Environment Agency. Copenhagen, Denmark.

EEA (1999). State and pressures of the marine and coastal Mediterranean environment, Environment Assessment Series(5). European Environment Agency. Copenhagen, Denmark.

Erol I, Cakar N, Erel D, Sari R (2009). Sustainability in the Turkish retailing industry. Sustain. Dev. 17(1): 49-67.

Europa (2009a). Available at: http://europa.eu/abc/keyfigures/index_en.htm, Accessed on: 1

Europa (2009b). Available at: http://europa.eu/legislation_summaries/regional_policy/management/

Eurostat (2007). Measuring progress towards a more sustainable Europe-2007 monitoring report of the EU sustainable development strategy, Eurostat Statistical Books. Luxembourg.

Eurostat (2009). Available at: http://epp.eurostat.ec.europa.eu/portal/page/portal/sdi/introduction,

Fistanic I (2006). Sustainable management of brackish Karst Spring Pantan (Croatia). Acta Carsol. 35(2): 65-72

Fornell C, Larcker, DF (1981). Structural equation models with unobservable variables and measurement error: algebra and statistics. J. Mark. Res. 18(3): 382-388.

Gabrielsen P, Bosch P (2003). Environmental Indicators: Typology and Use in Reporting: Working Papers. European Environment Agency. Copenhagen, Denmark.

Gefen D, Straub D, Boudreau MC (2000). Structural equation modeling and regression: guidelines for research practice. Commun. AIS. 7(7): 1-78.

Giddings B, Hopwood B, O'Brien G (2002). Environment, economy and society: fitting them together into sustainable development. Sustain. Dev. 10(4): 187-196.

Gobin A, Jones R, Kirkby M (2004). Indicators for pan-European assessment and monitoring of soil erosion by water. Environ. Sci. Policy 7(1): 25-38.

Golusin M, Ivanovic OM (2009). Definition, characteristics and state of the indicators of sustainable development in countries of South-eastern Europe Agriculture. Ecosystem Environ. 130(1/2): 67-74

ICLEI (1996). The Local Agenda 21 Planning Guide: an Introduction to Sustainable Development Planning. International Council for Local Environmental Initiative. Toronto, Canada.

Karageorgis AP, Kapsimalis V, Kontogianni A, Skourtos M, Turner KR, Salomons W (2006). Impact of 100-Year Human Interventions on the Deltaic Coastal Zone of the Inner Thermaikos Gulf (Greece): A DPSIR Framework Analysis. Environ. Manage. 38(2): 304-315.

Lee YJ, Huang CM (2007). Sustainability index for Taipei Environmental Impact Assessment Review 27(6): 505-521.

Mayer AL (2008). Strengths and weaknesses of common sustainability indices for multidimensional systems. Environ. Int. 34 (2): 277-291.

Matthews JW, Endress AG (2008). Performance criteria, compliance success, and vegetation development in compensatory mitigation wetlands. Environ. Manage. 41(1): 130–141.

Miller G, Twining-Ward L (2005). Monitoring for a Sustainable Tourism Transition: the Challenge of Developing and Using Indicators. Oxford University Press, New York.

Moran DD, Wackernagela M, Kitzesa JA, Goldfingera SH, Boutaudc A (2008) Measuring sustainable development-Nation by nation. Ecol. Econ. 64(3): 470-474.

Nunnally JC (1978). Psychometric Theory. 2nd Edition. McGraw Hill, New York.

Odermatt S (2004). Evaluation of mountain case studies by means of sustainability variables - A DPSIR framework as an evaluation tool in the context of the North-South discussion. Mt. Res. Dev. 24(4): 336-341.

Patlitzianas KD, Ntotas K, Doukas H, Psarras J (2007). Assessing the renewable energy producers' environment in EU accession member states. Energy Conversion Manage. 48(3): 890-897.

Rekolainen S, Kamari J, Hiltunen M, Saloranta TM (2003). A conceptual framework for identifying the need and role of models in the implementation of the Water Framework Directive. Int. J. River Basin Manage. 1(4): 347-352.

Segnestam L (2002). Indicators of Environment and Sustainable Development Theories and Practical Experience, Environmental Economics Series (89). The World Bank. Washington, D.C., U.S.A.

Simon S, Wiegmann K (2009). Modelling sustainable bioenergy potentials from agriculture for Germany and Eastern European countries. Biomass Bioenergy. 33(4): 603-609.

Smeets E, Weterings R (1999). Environmental Indicators: Typology and Overview. Technical Report No. 25. European Environment Agency, Copenhagen, Denmark.

United Nations (1996). Indicators of sustainable development framework and methodologies. New York.

Walmsley JJ (2002). Framework for measuring sustainable development in catchment systems. Environ. Manage. 29(2): 195-206.

Wei J, Zhao Y, Xu H, Yu H (2007). A framework for selecting indicators to assess the sustainable development of the natural heritage site. J. Mt. Sci. 4(4): 321-330

Wilson J, Tyedmers P, Pelot R (2007). Contrasting and comparing sustainable development indicator metrics. Ecol. Indic. 7(2): 299-314.

Yoon SW, Lee DK (2003). The development of the evaluation model of climate changes and air pollution for sustainability of cities in Korea. Landscape Urban Plan. 63(3):145-160.

Zhang Y, Zhao YW, Yang ZF, Chen B, Chen GQ (2009). Measurement and evaluation of the metabolic capacity of an urban ecosystem. Commun. Nonlinear Sci. Numer. Simul. 14(4): 1758-1765.

Zoeteman (2000). Rating the sustainability of nations. Ecosystem Health 6(4): 237 -245.