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Evaluating Green Public Procurement Practices: The Case of Polytechnics in Ghana

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Abstract: The paper introduces and develops a green public procurement practices (GPPP) analytical framework for the Ghanaian Public Sector involving six major practices including Acquisition and Material Specification Planning, Environmental Requirements, Green Purchasing, Strategic Supplier Partnership, Green Information & Communication Technology, and Employee Training. The study involved five Polytechnics in Ghana selected using random sampling and ten public procurement professionals from the five selected Polytechnics using a hybrid of convenient and purposeful sampling techniques. The data for the study was obtained using questionnaires and interviews techniques. A grey-based DEMATEL technique, a multi-criteria decision-making (MCDM) tool,was utilized to help identify the most influential major practice and important sub-practice in terms of the overall goal of achieving green economy. The MCDM tool revealed that 'Strategic Supplier Partnership' is the most influential major practice whilst 'Review of Material needs to include Green Procurement Requirements' was identified as the most important sub-practice. For the first time, a MCDM tool is utilized to identify the most influential and important GPPP for implementation in Ghanaian public sector. Finally, the paper will allow public sector procurement professionals to make thoughtful decisions on products and service purchases with a focus on environmental and societal consequences to achieve sustainable development.

Keywords: Green Public Procurement Practices, Grey-Based DEMATEL, Polytechnic Institutions, Ghana

1. Introduction

In the recent decades, green procurement activities have taken the central part of global warming discussion [1], [2], [3]. Green Procurement is defined as the approach to procurement in which decisions on environmental impacts play crucial roles in purchasing decisions [4]. On the other hand, green procurement can also be described as the selection of products or services which minimize environmental waste [5]. The green procurement discussion have centered more on environmental effects of what are been procured [5], [6], [11]. Most organizations require assessment of products or services to ascertain the environmental consequences of the entire products lifecycle which include raw materials, manufacturing, transporting, handling and storing, their use and disposal [5].

A number of aspects of the traditional procurement process may be adjusted to ensure green procurement is implemented [4],[5] The procedures include the identification and setting of environmentally friendly requirements, tendering, selection of contractors and purchasing products or services[4],[6]. Unlike the traditional procurement where departments and employees were required to submit purchase orders as well as requests on papers, green procurement will require them on electronic media to avoid or minimize paper usage. This suggests that company-wide environmental resource planning system may be needed for communication or information flow [4], [7], [8], [12], [13].

The environmental issue has gradually become a part of the corporate tradition [9]. The polytechnics are becoming more dynamic and innovative so new courses and projects are being

introduced. New technologies are coming up and competing among themselves. They need to adapt to the modern trend of technological changes, hence, have to deal with repeated processes of procuring new equipment and materials for their operations. Zhu et al (2007) [10] pointed out that procurement is frequent and that optimizing the procurement decisions to reduce relative cost is a critical cost strategy and development. It is therefore imperative for Polytechnic Institutions to identify the most effective green procurement practices for their operations. Effective green procurement practices will enhance the environmental performance of the Polytechnic Institutionsand contribute to their sustainable development.

The objective of this paper is to introduce and develop a green public procurement practices (GPPP) analytical framework for the Ghanaian Public Sector. The paper adopts a combined literature review and brainstorming among public procurement professionals to identify a potential GPPP framework. After identifying the potential GPPP framework, the framework will be subjected to initial review by some selected public procurement professionals to achieve a framework. The framework will furtherbe applied to the ten polytechnics in Ghana using the grey-based DEMATEL technique, a multi-criteria decision-making (MCDM) tool.

The rest of the paper is organized as follows. Section 2 presents the literature review. Section 3 discusses our research methodology. Section 4 elaborates on the data presentation and discussions. General conclusions and recommendations for future research are finally presented in section 5.

2. Literature Review

In order to understand the concept and identify the green public procurement implementation practices, it was necessary to explore and combine the literature under environmental management and public procurement. The literature reviewed depicted that, there was significant literature on Green Public Procurement (GPP) Practices in certain parts of Asia, Europe, and America; yet, there were significant numbers of nations that do not practice green procurement with Ghana not an exception.

The literature review revealed six (6) major green public procurement implementation practices and twenty three (23) sub-practices. The six major implementation practices adopted for this study are; Acquisition and Material Specification Planning (AMSP), Environmental Requirements(ER), Green Purchasing (GP), Strategic Supplier Partnership (SSP), Green Information Communication Technology (GICT), and Employee Training (ET) with the sub-practices put under their respective major practices. Table 2.1 below shows the Green Public Procurement Implementation framework.

We now overview the green public procurement practices framework using literature.

2.1. Acquisition and Material Specification Planning (AMSP)

Generally for companies to procure materials or productsrequire a planning stage where the procurement professionals decide on the necessity and specification of the product to purchase. This is also described as the product assessment stage. The professionals assess the material to ascertain the environmental impact of the product [4], [14]. Unlike the traditional indiscriminate purchasing habit of some organizations, at the AMSP stage of green procurement, the professionals establish the need for the product. They also determine the material specifications-which are the required characteristics thus, what should be included in the product including the content, energy efficiency [6], [8], [11], [17], [18]; recyclability, packaging [11], [17], [19], [20], [21]; delivery [18], [20], disposability[16], [18], [21], [31], [37].

That is, a thorough study of the environmental impact of the product to be purchased is undertaken [4], [15]. The professionals would like to assess the entire life cycle of the product ranging from theraw material extraction, manufacturing, packaging, transport, storage and utilization and disposal compared with the other similar available products[14],[15]. However, some organizations havedevelopedprocurement policy that include green requirement [17]. The green policy usually include purchase of less packaging products, products which use bio-materials, facilities which bear environmental friendly certifications or suppliers who are committed to environmental stewardship[4], [37]. The objective of the green policy is to enable the organizations to create a green procurement guide which provide green information [14], [15]. Such policies enable procurement experts to make required green decisions on products to be purchased [14]. [15], [17], [19], [21], [37].

One critical factor which can evolve inappropriate criteria and specification is lack of training on green acquisition and material specification planning of procurement [17], [18]. In a study of 25 member states, the report of [18] revealed that only two: Sweden and Germany added clear green specifications in just over 60%. Majority of the 25 states perceived that they were practicing green procurement but in reality they were not, due to inappropriate specifications. It should be noted that inappropriate and unclear specification can affect characteristics of the products acquired [18].

To buttress it, in 2007, the government of Japan took the initiative to promulgate a law that promoted the reduction of GHG in Japan state [20].

It is normal for organizations to assess their performance in regular periods and revise their operations to meet the current trend of technology and innovations. This may necessitate the procurement of new materials or new equipment [18], [20], [31], [37].

2.2. Environmental Requirements(ER)

The whole concept of green procurement is focused on protecting the environment from further pollution and if possible re-habilitates or improves upon it to make the earth healthy to live in. It is therefore appropriate for organizations to incorporate environmental requirements in their procurement criteria [19], [20].

Many institutions and organizations have adopted various

initiatives to promote the green environment. One of such initiatives is the use of mass transport [21].

Meanwhile studies have shown that certain organizations incorporate environmental management system in their operations to effectively coordinate and manage the entire environmental requirement [11],[15],[17],[18]]37].

A study undertaken by [15] reported that European Union (EU) public authority has implemented EMS in their green procurement activities. EMS follows a management cycle that requires coherency between executive priorities, procedures and reporting mechanisms in the system [15], [18], [31],[37]. It should be noted that without coherency in EMS,green procurement implementation is difficult to practice. Studies reveal that, certain Japanese companies practice green procurement by successfully integrating EMS at all levels in the company. Such companies include Ikea, Fujitsu and Japanese Travel Bereau[20],[21].

2.3. Green Purchasing (GP)

Green purchasing can be defined as all purchasing decisions and award of contracts that are based on environmental friendly factors as well as other factors such as price and quality [19]. However Green purchasing can also be defined as the environmental desirable purchasing such as eco-friendly products [11]. It involves the decision to buy products and services that are free from environmental toxins and hazards [11], [21], [35].

Green purchasing does not only contribute positively to the environmental protection, but it also creates avenue for awareness [15], [3], [11], [32], [33]. Thus the environmental protection does not lie in the care of environmental protection agencies only, but it also lies in the care of procurement managers [3],[11[35].It suggests that green procurement is an essential concept that should be embraced by all organizations and institutions in order to sustain the environment and maintain healthy life [11], [35],[31],[37], [43].

The European Union(EU) and the International Standard Organization(ISO) are some of the institutions that ensure manufacturing companies meet certain international green requirements[13],[22], [31],[37], [43].

One easiest way for procurement experts to identify green products is the eco-labeling [13], [19],[22],[31] [34],[37], [43]. Products labeled "ISO"," Blue Angel", "Austrian Tree", "Nordic Swam" and "EU flower" are a few of the famous reliable eco-labels[13],[31],[37]. Studies have shown that eco-labeled products are more environmental friendly compared with the similar or alternative options [13]. [23], [33].

There is an EU tool which enables organizations to perform proper green management audit [13], [19], [24].

Studies have shown that in 1993, a number of recycling organizations evolved in USA which aimed at improving waste management. Such organizations included Industrial Materials Exchange (IMEX), Gifts In Kind America, California Integrated Waste Management Board and California Material Exchange (CALMAX) among others [12], [37], [43].

Table 2.1. *Green Public Procurement Practices (GPPP) Implementation Framework.*

Pos	Major Practices	Sub-Practices	Literature
1	Acquisition and Material Specification Planning(AMSP)	Energy efficient and power standby devices requirement (AMSP1)	USA DoD1 (2004);Wang and Wu(2004);ECFESOPEC2(2001);UNSD3(2012); OOFEC4(2013)
		Recyclable products and materials requirements(AMSP2)	UNSD(2012);US EPARV5(1999);OOFEC(2013); USA DoD(2004)
		Meeting green procurement requirements prior to contracting(AMSP3)	UNSD(2012);Plas et al.(2000);Wang and Wu(2004);USEPARV(1999)
		Review of material needs to include green procurement requirement(AMSP4)	USADoD(2004);ECFEOSPEC(2001);UNSD(2012);OOFEC(2013)
2	Environmental Requirements(ER)	Environment Management System(ER1)	US EPARV(1999);OOFEC(2013);USA DoD(2004)
		Bio-based products(ER2)	USA DoD(2004);ECFESOPEC(2001); UNSD(2012)
		Environmental friendly and safe disposal products(ER3)	ECFESOPEC(2001);Plas et al(2000);Mine & Galle(1997)
3	Green Purchasing(GP)	Purchasing of eco-labelled products(GP1)	USA DoD(2004); ECFESOPEC(2001); UNSD(2012);Chien& and Shih(2007); OOFPEC(2013);Panasonic6(2014)
		Purchasing of recyclable products(GP2)	Ho et al(2010); Panasonic (2014); USA DoD(2004)
		Green supplier selection using environmental information(GP3)	Chien& Shih(2007); OOFPEC(2013); USA DoD(2004)
		Green supplier performance assessment(GP4)	US EPAR V(1999); Min & Galle(1997)

1 US Department of Defense

2 European Consultative Forum on Environment, Sustainable Develop and Office of official Publications of European Communities

3 UN Secretary of Defense

4 Office of Official Publication of European Communities

5 US Environmental Protection Agency, Region V

6Panasonic Green Procurement

Pos	Major Practices	Sub-Practices	Literature
4	Strategic Supplier Partnership(SSP)	Integration of information system with key suppliers(SSP1)	Ho et al(2010);OOFEC(2013);Panasonic(2014)
		Regular supplier audit to ascertain meeting green requirements(SSP2)	US EPAR V(1999);USA DoD(2004)
		Green information sharing with strategic supplier partners(SSP3)	Ho et al(2010);USA DoD(2004)
		Supplier location and/or delivery method(SSP4)	Ho et al(2010)
5	Green Information Communication Technology(GICT)	Teleworking(GICT1)	Driscoll(2010);Naveen et al(2009)
		Use of e-Ordering system(GICT2)	Driscoll(2010); Neupane et al(2004)
		Use of company-wide ERP system(GICT3)	Driscoll(2010); Neupane et al(2004)
		Use of energy efficient computing(GICT4)	Driscoll(2010);Naveen et al(2009); USA DoD(2004)
		Intelligent network system(GICT5)	Boucher et al(2001); Dugan et al(2002)
6	Employee Training(ET)	Initial awareness training on green procurement systems(ET1)	Wang and Wu(2004)
		Refresher training on green procurement goals(ET2)	Wang and Wu(2004);DoD(2004); Bouwer et al; (2006);Plas and Erdmenger(2002);Bouwer et al(2006)
		Annual training on green procurement systems(ET3)	USA DoD(2004);Wang and Wu(2004);

2.4. Strategic Supplier Partnership (SSP)

In order for an organization to establish effective environmental system, there must be effective integration with the various organizations involved in a project. This enables experts to undertake proper environmental impact assessment [26]. Research shows that proper environmental impact assessment depends on effective communication between all experts and organizations involved in a business or project [26].

It is therefore imperative to integrate key supplier and customer information systems for free information flow between the organizations. However the field interview indicated that integration of information system with key supplier cannot be applied in public procurement where in the view of transparency and fairness, tender is made open.Meanwhile, studies show that public institutions usually have external auditor who regularly audit the records to determine transparency and maintain corruption free organizational setting [15]. For instance, EU developed a legal framework for an "Environmental Management and Audit Scheme (EMAS) to monitor green public procurement [15].

However Art and Faith-Ell, (2010) [26] believed that if suppliers are made to implement EMS and are monitored, it will enable efficient green environmental auditing. They argued that the EMS will enable the contracting organizations to regularly evaluate contractors green environmental performance to ascertain their level of compliance to international standards.

2.5. Green Information Communication Technology (GICT)

Organizations which practice green procurement require new data and information about the environment, the impact of the various products and the effects so that they can introduce green innovations into their operations [11], [27], [26]. GICT is the concept of practicing green procurement via the application of information communication technology.

Proper management of GICT reduces the carbon (VI) oxide, CO_2 and carbon (II) oxide, CO emissions. In addition, it builds transparency, accountability and eliminates redundancy in public procurement and maximizes energy efficiency [8], [29].

Studies revealed that the Republic of Bangladesh developed e-Government Procurement (e-GP) portal in 2006 which was manned by Central Procurement department. It is reported that the portal increased transparency, value for money, competition among bidders, quality, and accountability and reduced barriers in their procurement [29] Further studies indicated that countries which have instituted GICT and are benefiting from it include Czech Republic, Denmark, Germany, Greece, Hong Kong, Hungary, Japan, Korea (South), Malaysia, New Zealand, Netherlands, Philippine, Thailand, Turkey, UK, USA and VietNam[29].

Following advancement in technology, tele-working has become one method of implementing green [14]. Works that can be performed electronically include order processing; invoice processing, contract processing and management [14], [31].

2.6. Employee Training (ET)

For green procurement to take strong root, the various stakeholders must understand the entire concept [13], [14], [18]. One important stakeholder is the employees who put the green concept into real practice. The incorporation of the environmental factors into the criteria for purchasing requires parallel steps to train and motivate the employees [13].In fact training on green procurement is an integral part of green implementation practice in any organization [13], [14],[44].

Generally green training is categorized into two levels, including: (1) initial general introduction (this level is what this study refers to as initial awareness stage), (2) the detailed green procurement training. Some organizations separate the detailed green procurement training into (a) refresher green training and (b) the annual green training[13], [18].

3. Research Methodology

In order to achieve the set objective of the research, this study proposed and utilized a grey-based DEMATEL model. The methodology involves a two-phase data collection process: the first-phase focused on a simple YES/NO questionnaireaiming to validateand conceptualize the selected green public procurement criteria and indictors from literature relevant to the study for effective implementation. The second-phase uses real field study approach facilitated by questionnaire to seek public procurementprofessionalsopinion through pair-wise comparison influence matrices to measure the complex influence among the criteria and indicatorsand validate the proposed grey-based DEMATEL model [5], [8], [11], [18], [19],[20],[26],[32],[33],[37],[43].

3.1. Overview of Grey Theory

The grey system theory was developed by Deng in 1982 to deal with problems with uncertainty or systems with a lot of setbacks and imperfect or incomplete information. [38],[39],[40] .

Table 3.1. *The Linguistic variables and grey numbers for Criteria weighting.*

Linguistic Terms	Linguistics Variables	Grey Numbers
No Influence	N	(0,0,)
Very Low Influence	VL	(0,0.25)
Low Influence	L	(0.25,0.50)
High Influence	H	(0.50,0.75)
Very High Influence	VH	(0.75,1.00)

3.2. Some Basic Grey Mathematical Definitions are Presented Below

Let us define x_{ij}^{p} as the grey number for a expert (decision maker p) evaluation of the influence of factor$i$on factor$j$.Let l and r be the lower and the upper limits respectively, then the grey number for the lower limit is xl_{ij}^{p} and that of the upper limit is xr_{ij}^{p} respectively.

Transformation of the grey numbers into crisp numbers (scores) is necessary. We therefore adopt the modified-CFCS (Converting Fuzzy data into Crisp Scores) defuzzification method for this operation.The modified-CFCS method involves three key steps to convert grey numbers into crisp numbers and is given below:

Step 1: Normalization:

$$xr_{ij}^{p} = \left(r_{ij}^{p} - minl_{ij}^{p}\right)/\Delta_{min}^{max} \quad (1)$$

$$xl_{ij}^{p} = \left(l_{ij}^{p} - minl_{ij}^{p}\right)/\Delta_{min}^{max} \quad (2)$$

$$\Delta_{min}^{max} = maxr_{ij}^{p} - minl_{ij}^{p}$$

Step 2: Compute total normalize crisp values:

$$x_{ij}^{p} = \left[xl_{ij}^{p}\left(1 - xl_{ij}^{p}\right) + \left(xr_{ij}^{p} \times xr_{ij}^{p}\right)\right]/\left[1 - xl_{ij}^{p} + xr_{ij}^{p}\right] \quad (3)$$

Step 3: Compute crisp values:

$$z_{ij}^{p} = minl_{ij}^{p} + \left(x_{ij}^{p} \times \Delta_{min}^{max}\right) \quad (4)$$

Step 4: Integrate crisp data matrices:

$$z_{ij} = \frac{1}{h}\left(z_{ij}^{1} + z_{ij}^{2} + \cdots + z_{ij}^{h}\right) \quad (5)$$

3.3. Overview of DEMATEL (Decision Making Trial and Evaluation Laboratory)

DEMATEL is a structured analysis tool developed at the Geneva Research Centre of the Battelle Memorial Institute [27], [45], to help determine the causality of criteria in relatively small sample size setting [46]. DEMATEL helpsto effectively evaluate complex relationship amongst implementation criteria and support management strategic decision using the influence relationships shown on digraphsor in some cases uses matrices. In our case, DEMATEL is used to evaluate the green public procurement implementation practices and sub-practices for both influence relationship (major practices) and importance rankings (sub-practices). DEMATEL method follows four basic step-wise processes [27].

Step1: Develop the initial pair-wise direct-relation matrix and find the average matrix

Given that there are *h* experts available to solve a complex interdependent problem and there are *n* practices to be considered, if each expert gives n× *n* non-negative feedback matrix,x^{p} with $1 \leq p \leq h$. This implies thatx_1, $x_2 \ldots x_h$ are the feedback matrices for each of the *h* experts, each element of x^{p}, is an integer denoted by x_{ij}^{p}. $x^{p} = \left[x_{ij}^{p}\right]n \times n$ .The diagonal elements of each feedback matrixx^{p}, are all set to zero. We can then compute the n×n average matrix A by averaging the h experts score matrices. The (i,j)element of average matrix A is denoted by:

$$\left[a_{ij}\right]n \times n = \sum_{p=1}^{h}\left[x_{ij}^{p}\right] n \times n \quad (6)$$

The average matrix$\left[a_{ij}\right]n \times n$is called the direct-influence matrix which indicates the initial direct effect of row practice i on the column practice j.

Step 2: Normalize initial direct-relation matrix D

Normalize initial direct-relation matrix is obtained using Eqs. (7) and (8) below:

$$s = max\left\{max\sum_{j=1}^{n} a_{ij}, max\sum_{i=1}^{n} a_{ij}\right\} \quad (7)$$

$$D = \frac{A}{S} \quad (8)$$

Step 3: Determine the total direct-relation matrix

The total relation matrix *T* is determined by using Eq. (9) below

$$T = D^{1} + D^{2} + \cdots + D^{p} = D(I - D)^{-1} \quad (9)$$

Where I is identity matrix

Step 4a: Calculate the sums of rows and columns of matrix T

In the total-influence matrix *T*, the sum of all rows and the sum of all columns are represented by vectors *r* and*c* respectively.

$$T = [t_{ij}]n \times n \text{ , i, j = 1, 2, 3…..n}$$

$$r_i = \sum_{j=1}^{n} t_{ij} \, \forall_i \quad (10)$$

$$c_j = \sum_{i=1}^{n} t_{ij} \, \forall_j \quad (11)$$

Step 4b: Determine the overall importance/prominence (P_i) and net cause/effect (E_i)

$$P_i = (r_i + c_j / \, i = j) \quad (12)$$

$$E_i = (r_i - c_j / \, i = j) \quad (13)$$

The greater the P_i value, the greater the influence of the practice i with respect to the overall relationship. If$E_i > 0$, then practice i is a net cause for other practices. If$E_i < 0$, practice $i$receives the net effect [47].

Step 4c: Set a threshold value to filter the minor relationship amongst the criteria from the total-relational matrix and plot digraph

A threshold is set to filter the minor relationships from within the total-relation matrix. The relationships above the agreed threshold and P_i and $E_i$values are combined to plot a directional graph (digraph) to display the cause and effects relationships among the practices [41], [42].

3.4. Proposed Grey-Based DEMATEL Methodology

This is an integration of the grey theory and the DEMATEL methodology. The computational steps involved with the proposed methodology are as follows:

Step 1: Obtain the initial linguistic rating direct-relation matrix from all experts/decision-makers using the linguistic variables shown on Table 3.1 column 2.

Step 2: Reassign the initial linguistic direct-relation matrix for all experts/decision-makers with equivalent grey numbers from Table 3.1 column 3.

Step 3: De-grey the grey initial direct-relation matrix to achieve crisp values/data following Eqs. (1) – (4) for all experts/decision-makers

Step 4: Integrate all experts/decision-makers crisp datamatrices into a single crisp data matrix using Eq. (5)

Step 5: Normalize the aggregated crisp initial direct-relation matrix using Eqs. (7) & (8).

Step 6: Determine the total direct-relation matrix using Eq. (9)

Step 7: Determine the overall importance/prominence and net cause/effect using expressions (10) and (11).

Step 8: Set or agree on a threshold value to filter the minor criteria relationships from within the total-relation matrix and plot the digraph.

3.5. The Study Setting

This study focused on Green Public procurement with special recognition to the ten Polytechnics in Ghana. The Polytechnics in Ghana are becoming more dynamic and innovative so new courses and projects are being introduced. New technologies are coming up and competing among themselves. They need to adapt to the modern trend of technological changes, hence, have to deal with repeated processes of procuring new equipment and materials for their operations. The pressing need for polytechnic institutions to greening their operations is becoming increasingly important. This has motivated us to initiate this study to investigate and attempt to identify the most important criteria and indictors that can contribute to greening the Ghanaian polytechnic institutions operations.

3.6. Population and Sample and Sample Technique

3.6.1. Population

In order to identify the major and sub practices of green public procurement implementation practices, all the ten Polytechnic institutions in Ghana were considered as the entire population.

3.6.2. Sample and Sample Techniques

Due to the nature of the study, random sampling was used to sample five of the Polytechnic Institutions. The sampled Polytechnic Institutions included Kumasi Polytechnic, Koforidua Polytechnic, Sunyani Polytechnic, Tamale Polytechnic and Wa Polytechnic.

Furthermore, due to the availability of the experts, a hybrid of convenient and purposive sampling was adopted to select the sample from the five Polytechnic Institutions. Ten public procurement professionals from the five Polytechnics inGhana, who availed themselves and had the requisite capacity, were selected for their inputs in the framework development and respond to the interview and the questionnaire.

3.7. Linguistic-Based Questionnaire Design and Pilot Testing

The authors administered two-phases of questionnaires in the study. Each of the questionnaires had five parts- the demography of the respondents, the cover letter, introduction which provided detailed explanations of how the questions would be answered, followed by the questions and definition of abbreviations. The introduction section of the second questionnaire had a sample question to guide the procurement professional when answering the main questions.

3.8. Data Collection

The authors partially self-administered the questionnaires and through e-mails. Series of follow-ups were done after thequestionnaires weredistributed to ascertain if the procurement professionals encountered any challenge when completing the questionnaire.

3.9. Validity and Reliability

3.9.1. Validity

The questionnaire was developed based on the literature review. This was to ensure that the procurement professionals know and understandwhat they were responding to. Further explanations were given to the procurement professionals to ensure that they provided valid responses.

3.9.2. Reliability

Self-administered questionnaire and interviews were conducted in order to minimize completely data collection biases.

3.10. Data Analysis

The data collected were methodologically analyzed using the proposed grey-based DEMATEL model aided by Microsoft Office Excel and Matlab.

4. Data Presentation and Discussions

4.1. Application of the Proposed Grey-Based DEMATEL Methodology to a Real Case

This study adopted literature review and procurement professionals input to arrive at the theoretical framework. This theoreticalframework was then evaluated with the aid of the proposed grey-based DEMATEL model with inputs from the public procurement professionals. The application of the proposed model was completed in two-stages. The first-stage dealt with the major practices whist the second-stage dealt with the sub-practices.

Stage-1: Major Practices Application

Theproposed methodology procedure is as follows:

Step 1: Obtain the initial direct-relation matrix.

Table 4.1 below is the direct-relation matrix completed by expert-1.

Table 4.1. *Manager-1 Direct-relation matrix for major practices.*

Major practices	AMSP	ER	GP	SSP	GICT	ET
AMSP	0	***H***	VH	VH	VH	VH
ER	H	0	H	VH	H	VH
GP	H	VH	0	VH	VH	VH
SSP	H	H	VH	0	H	VH
GICT	H	L	VH	H	0	VH
ET	VH	VH	VH	VH	VH	0

Step 2: Assign linguistic initial direct-relation matrix with grey numbers.

To address the vagueness in the responses from the experts, we used expert1's response as an illustration. Let us consider element $a_{12} = H$from expert 1 response from Table 4.1 and assign the linguistic variable ***H*** with the grey value (0.50, 0.75) at the intersection of AMSP and ER. The rest of the linguistics variable grey assignments are shown in Table 4.2 below.

Table 4.2. *Expert-1Direct-relation matrix for major practices reassigned with grey numbers.*

Major practices	AMSP	ER	GP	SSP	GICT	ET
AMSP	0	(0.50, 0.75)	(0.75, 1.00)	(0.75, 1.00)	(0.75, 1.00)	(0.75, 1.00)
ER	(0.50, 0.75)	0	(0.50, 0.75)	(0.75, 1.00)	(0.50, 0.75)	(0.75, 1.00)
GP	(0.50, 0.75)	(0.75, 1.00)	0	(0.75, 1.00)	(0.75, 1.00)	(0.75, 1.00)
SSP	(0.50, 0.75)	(0.50, 0.75)	(0.75, 1.00)	0	(0.50, 0.75)	(0.75, 1.00)
GICT	(0.50, 0.75)	(0.25,0.50)	(0.75, 1.00)	(0.50, 0.75)	0	(0.75, 1.00)
ET	(0.75, 1.00)	(0.75, 1.00)	(0.75, 1.00)	(0.75, 1.00)	(0.75, 1.00)	0

Step 3: De-grey the grey initial direct-relation matrices

To covert the grey rating/response of the experts into crisp values requires the need to de-greyusing Eqs. (1) - (4). Again, considering the grey valuesat $a_{12} = (0.50, 0.75)$ for expert 1 in Table 4.2, we followed the following steps:

Step 3.1: Normalize grey:

$$\Delta_{min}^{max} = (1 - 0.25) = 0.75$$

$$xr_{ij}^{1} = \frac{(0.75 - 0.25)}{0.75} = 0.6667$$

$$xl_{ij}^{1} = \frac{(0.5 - 0.25)}{0.75} = 0.3333$$

Step 3.2: Compute total normalize crisp values:

Eq. (3) is used to compute the normalized crisp values. The normalized crisp value for exper-1 is computed as shown below.

$$x_{ij}^{1} = \frac{[0.3333(1 - 0.3333) + (0.6667 \times 0.6667)]}{[1 - 0.3333 + 0.6667]} = 0.5$$

Step 3.3: Compute crisp values:

The total crisp value of manager-1 is computed using Eq. (4). The total crisp value of expert-1 is as shown below.

$$z_{ij}^{1} = 0.25 + (0.5 \times 0.75) = 0.625$$

Step 4: Aggregate crisp data matrices of all experts:

The aggregate crisp data matrixwas obtained by using Eq. (5). Table 4.4 below depicts the aggregated crisp matrix.

Table 4.3. *Total Crisp data of expert-1.*

Major practices	AMSP	ER	GP	SSP	GICT	ET
AMSP	0	0.625	0.938	0.938	0.938	0.938
ER	0.625	0	0.625	0.938	0.625	0.938
GP	0.625	0.938	0	0.938	0.938	0.938
SSP	0.625	0.625	0.938	0	0.625	0.938
GICT	0.625	0.313	0.938	0.625	0	0.938
ET	0.938	0.938	0.938	0.938	0.938	0

Table 4.4. *Aggregated crisp matrix for all experts.*

Major practices	AMSP	ER	GP	SSP	GICT	ET
AMSP	0	0.628	0.569	0.713	0.644	0.869
ER	0.641	0	0.716	0.478	0.550	0.719
GP	0.641	0.944	0	0.644	0.569	0.794
SSP	0.484	0.638	0.794	0	0.563	0.791
GICT	0.566	0.409	0.869	0.488	0	0.869
ET	0.794	0.794	0.719	0.566	0.706	0

Step 5: Normalize initial crisp direct-relation matrix.
Table 4.5 depicts the normalized initial crisp direct-relation matrix of all the experts

Table 4.5. *Normalized initial direct-relation matrix of all the experts.*

Major practices	AMSP	ER	GP	SSP	GICT	ET
AMSP	0	0.175	0.158	0.198	0.179	0.242
ER	0.178	0	0.199	0.133	0.153	0.200
GP	0.178	0.263	0	0.179	0.158	0.221
SSP	0.135	0.178	0.221	0	0.157	0.220
GICT	0.158	0.114	0.242	0.138	0	0.242
ET	0.221	0.221	0.200	0.158	0.197	0

Step 6: Determine the total direct-relation matrix.
Table 4.6 displays the total direct-relation matrix

Table 4.6. *Total direct-relation matrix.*

Major practices	AMSP	ER	GP	SSP	GICT	ET	R
AMSP	2.336	2.671	2.766	2.320	2.408	3.047	15.559
ER	2.308	2.329	2.591	2.107	2.214	2.797	14.346
GP	2.577	2.831	2.728	2.388	2.478	3.140	16.141
SSP	2.373	2.586	2.717	2.077	2.310	2.929	14.992
GICT	2.364	2.513	2.701	2.174	2.150	2.913	14.815
ET	2.602	2.795	2.890	2.369	2.501	2.955	16.112
C	14.559	15.725	16.393	13.436	14.062	17.780	91.954

Step 7: Determine the overall importance/prominence and net cause/effect of the practice (criteria).

The overall importance of the practices and sub-practices are determined based on the final weights after adding the row sums to the column sums and the greater the better. Additionally, the net cause/effect is also determined based on the final weights after subtracting the column sums from the row sums and the greatest the better. This is further put into two main groups. Cause group with positive final weights and effect with negative final weights. Table 4.7 below depicts the weights of all the major practices.

Table 4.7. *Relative Weights(R+C) and net cause-effect(R-C) values of practices.*

	AMSP	ER	GP	SSP	GICT	ET
R	15.559	14.346	16.141	14.992	14.815	16.112
C	14.559	15.725	16.393	13.436	14.062	17.780
R+C	30.118	30.071	32.534	28.428	28.877	33.892
R-C	1.000	-1.379	-0.252	1.556	0.753	-1.668

Step 8: Set a threshold value to eliminate some of the minor effect elements from the matrix. To minimize the complexity of the digraph for a more manageable relationship, we set a threshold to helpfilter and only display relationships above the set threshold considered most influential. Table 4.8 depicts the values above the threshold values.

Table 4.8. *Shows the values above the threshold value.*

Major practices	AMSP	ER	GP	SSP	GICT	ET
AMSP	2.336	*2.671	*2.766	2.320	2.408	*3.047
ER	2.308	2.329	*2.591	2.107	2.214	*2.797
GP	*2.577	*2.831	*2.728	2.388	2.478	*3.140
SSP	2.373	*2.586	*2.717	2.077	2.310	*2.929
GICT	2.364	2.513	*2.701	2.174	2.150	*2.913
ET	*2.602	*2.795	*2.890	2.369	2.501	*2.955

Threshold = 2.554, Values above threshold value*

The relative importance and the net cause/effect weights combined with the major practices influence relationships above set threshold dataset were used to plot a directional graph (digraph). This digraph is shown in Figure 4.1 below.

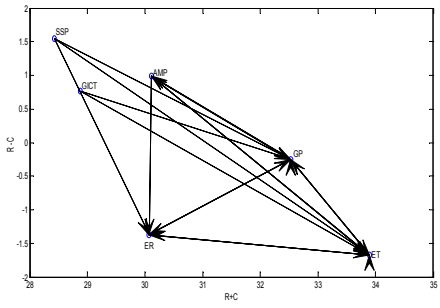

Figure 4.1. *Diagraph of the relationship among the major GPPIP.*

Stage -2: Sub-Practices Application.

The sub-practices application and computation followed similar procedure as the major practices but stopped at step 7. In step 7 however, we only computed the importance/prominence of the sub-practices since we only needed to rank the sub-practices based on the relative importance weights.

Table 4.9 depicts the sum of rows and sum columns. It also shows the addition of the sum of rows and sum of columns to achieve the relative importance weights or prominence of the sub-practices. Furthermore, the sub-practices are ranked in descending order using the relative importance weights as shown in Table 4.10.

Table 4.9. *Relative importance/prominence Weights(R+C) of sub- practices.*

	AMSP1	AMSP2	AMSP3	AMSP4	.	ET1	ET2	ET3
R	6.007	6.305	6.618	7.199	.	6.142	7.237	6.612
C	6.358	7.017	6.886	7.080	.	6.323	7.012	6.597
R+C	12.365	13.321	13.504	14.278	.	12.465	14.249	13.208

Table 4.10. *The ranking of the sub-practices.*

Practice	Weight	Rank	Practice	Weight	Rank
AMSP4	14.278	1	GP4	13.129	12
ET2	14.249	2	SSP3	12.948	13
ER3	14.190	3	SSP1	12.911	14
SSP2	14.180	4	ET1	12.465	15
ER1	13.938	5	AMSP1	12.365	16
GP1	13.796	6	GICT2	12.337	17
GP3	13.625	7	GICT4	12.251	18
AMSP3	13.504	8	GICT5	12.062	19
GP2	13.355	9	GICT1	12.017	20
AMSP2	13.321	10	GICT3	11.841	21
ET3	13.208	11	ER2	11.357	22

4.2. Discussion and Analysis

This section will consider the analysis of the major practices followed by the sub-practices.

4.2.1. Part 1: Discussion and Analysis of Major Practices

This part presents the cause-effect relationship analysis from digraph followed by the analysis of the results of the major practices.

4.2.2. The Cause-Effect Relationship (Diagraph) Among the Major GPPIP

Figure 4.1 (digraph)shows that SSP influences ER, ET and GP whilst GICT influences ER, GP. AMSP influences ER, ET and GP whilst ER influences ET and GP. Close observation of the digraph shows that GP also influences ER, ET, and AMSP whereas ET influences ER, GP, AMSP and itself. Table 4.9 below shows the summary of the cause-effect relationship among the major GPPIPs.

Table 4.11. *Summary of the relationship among major GPPIPs.*

Pos	Cause Practices	Influencing Practices
1	SSP	ER,ET,GP
2	GICT	ET,GP
3	AMSP	ER,ET,GP
4	ER	ET,GP
5	GP	ER,ET,AMSP
6	ET	ER,ET,GP,AMSP

The major GPPIPs were divided into:

- Cause category
- Effect (Influenced) category as shown in Table 4.11 above

Table 4.12. *Shows the cause and effect groupings for major practice.*

Cause group	R-C value	effect group	R-C value
SSP	1.556	ET	-1.668
AMSP	1.000	ER	-1.379
GICT	0.753	GP	-0.252

4.2.3. Analysis of the Results of Major GPPIPs

The values of R-C indicate the net cause and effect of one practice on another practice. All the positive values of the major GPPIP were categorized as cause group. These practices influence other practices more than they are being influenced. The highest positive value of R-C means the practice has the most influence (impact) on others. The results on Table 4.7 depicts that SSP, AMSP and GICT have positive R-C values of 1.55, 0.99, and 0.76 respectively, hence considered the cause practices. However SSP (Strategic Supplier Partnership) has the highest positive value of 1.55, hence considered as the practice with the most direct influence on the others. Thisimplies that SSP is the most influential practice for management consideration. This could mean that, in a system of interdependent six GPPIPs identified, if SSP is improved, the entire system may improve significantly. It further suggests that, if SSP is well resourced, the entire system benefits accordingly.

The negative values of R-C mean that, the practice is being influenced (affected) by others more than they influenced others. The results on Table 4.7 indicates that ET, ER and GP have negative R-C values of -1.67, -1.37, -0.25 respectively, hence considered as the effect practices (refer to Table 4.12). ET (employee training) has the highest negative value of-1.67 hence considered the most directly affected practice by the other practices. Considering the relative importance of the practices, ET was identified as the practices with the highest relative importance weights of 33.89 whilst SSP observed as the practice with the least relative importance weight of 28.43 (refer from Table 4.7).

From the results, employee training is considered the most important major practices whilst strategic supplier partnership is considered the least important practices. On the contrary, employee training is categorized under the effect group and considered the highest effected practice within the effect group whilst strategic supplier partnership is categorized under the cause group and considered the highest caused

practice within the cause group. This may mean that, because the concept of green public procurement is relatively new to the Ghanaian public sector in general and the polytechnic in particular, there is a nature tendency for the polytechnic to encounter enormous difficulties during the green concept program implementation hence in the absence of employee training, the program is bound to achieve worsened results or may end up unsuccessful as such the experts considered employee training as the topmost important practices. It may also mean that, strategic supplier partnership may have been developed already from the traditional public procurement strategy given it the highest causation as a result their importance may be less needed for this implementation requiring the strong need of the less mature GPPIP practices such as employee training.

Therefore, for the program to survive and exceedingly succeed, requires the need for strong employee training (ET), as well as educating the general polytechnic staffs on the new procurement strategy. This finding is in line with [19]argument that, for an organization to strongly incorporate environmental factors into the criteria for purchasing and become successful, requires parallel steps to train and motivate their employees. It is therefore clear from this study that SSP and ET are the two key significant practices that may drive the success of the green public procurement implementation in the Ghanaian polytechnic institutions.

4.2.4. Analysis of Sub-Practices

The GPPIP that has the highest weight is considered the most important practice. Table 4.10 indicates that AMSP4 is the most important practice with the highest weight of 14.28. On the other hand, ER2 is considered the least important with sub-practice since it has the smallest weight of 11.36. Thus, AMSP4 and ER2 take the first and the twenty-second positions respectively on the ranking as shown on Table 4.10. Review of material needs to include green procurement requirement (AMSP4) is considered the most important sub-practices amongst others. This may sound right since the whole procurement strategy commence with establishment of the requirements for the needs and that if at this stage the procurement staffs together with the internal customers/users incorporate the green concept before communicating the needs to the supplier, it will be a good start. Bio-based products (ER2) are considered the least important sub-practices probably because the green concept is still in the fancy in the country, public sector and polytechnic. This advanced approach to addressing the environmental issues will need time for the polytechnic to adopt and mature to a certain level before moving to the advance stage. Taking up such practice may be less beneficial,less attractive and expensive.

5. General Conclusions and Recommendations for Future Research

This paper introduced and developed an analytic framework for green public procurement implementation in the public sector of Ghana using a combination of literature review and public procurement professional opinions. Additionally, we assessed complex relationships among the practices and the most important sub-practice in terms of the overall goal of achieving green economy.

Based on the six major practices and twenty two sub-practices, the study proposed and applied the grey-based DEMATEL methodology to analyze and prioritize the practices. The study identified that the most influential major practice was SSP and the most vulnerable or affected major practice was ET. However the ET had the highest weight to indicate that it was the most prominent practice. Among the sub-practices, the most prominent was identified as AMSP4, and ER2 was the least prominent.

The study findings support some prior researches. Earlier researches suggest that Employees training is crucial for management of green procurement implementation [14], [18], [19], [26]. In order for an organization to establish effective environmental system, there must be effective integration with the various organizations involved in a project [26].

5.1. Managerial Implications

The following important managerial implications are obtained from the proposed methodology with its application to green public procurement implementation practices. The proposed grey-based DEMATEL methodology provided general decision making framework for green public procurement implementation practices (GPPIPs). Thus, procurement managers can plan their activities along the relative importance of the practices. Again managers confronted with green procurement resources challenge can apply the proposed grey-based DEMATEL methodology to identify which practices influence others the most using the diagraph. The diagraph provides relationship on which GPPIPs should be emphasized and resourced to improve the system. State agents can also use information in the study to examine public procurement policies. Lastly, the results of the study cannot be a generalization of GPPIPs. It is therefore imperative for managers to perform critical analysis since the results of this study were based only on experts in five Polytechnic Institutions.

5.2. Further Research

In terms of further research, researchers can adopt our proposed analytical frameworkand grey-based methodology to conduct to conduct further similar studies in the developing nation and try to compare the results.Other researchers might study green public procurement implementation practices in other sectors of the economy using the proposed methodology.Further extension of the methodologyto include ANP, GRA or even fuzzy-based DEMATEL may be an interesting tool to further investigate the level of maturity of the green concept in the developing countries using our proposed analytical framework will be an interesting area for future research.

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