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Simultaneous Optimisation of Supply Networks in the Floriculture Industry in Kenya: Quantitative Research Process Using Principal Component Analysis

[1]Tom K'Awino, [2] Emmanuel Awuor

[1]Head of Marketing, Management University of Africa
[2]Professor (Associate), Management University of Africa

ABSTRACT

The paper presents quantitative research process in developing a conceptual model for simultaneous optimisation of supply networks in the floriculture industry in Kenya. Use of principal component analysis first led to the extraction of fifteen factors with loadings greater than 1.0. Followed by forced extraction of four and five factors with loadings greater than 0.490. This was meant to reflect on the proposed conceptual model. Prior to performing principal component analysis the suitability of data for factor analysis was assessed. Inspection of the correlation matrix revealed the presence of many coefficients of .3 and above. The Keiser-Meyer-Oklin value was .961, exceeding the recommended value of .6 and the Bartlett's test of sphericity reached statistical significance, supporting the factorability of the correlation matrix. This phase of the study was instrumental in answering the following research sub-questions: what are the key success factors that influence the performance of the floriculture industry in Kenya?, what are the factors that will indicate performance of the floriculture industry from a traditional perspective (supplier-customer)?, are there differences in factors to be considered for the embedded and free agents performance in the floriculture industry, end to end and within country?, what needs to be considered in developing a conceptual model for simultaneous optimisation of supply networks?The results of the study points at: financing; key success factors (supply value chain); country specific benefits; transport; research and development as positively influencing the performance of the floriculture industry in Kenya. This findings and results were fundamental in developing a conceptual model for simultaneous optimisation of the floriculture industry. Impacting positively on performance of the industry.

Key words: Factor analysis; principal component analysis; verimax rotation

1.0 INTRODUCTION

Increasing complexity in the global supply chains has made many companies realize that supply chain management (SCM) is a critical business element, and no longer the domain of the warehouse manager or logistics director. While much talk has surrounded the concept of supply chain management, very few companies are seizing the potential found in its broad scale adoption (Goldsby and Martichenko, 2005:12). The complexity of the floriculture industry calls for effective optimization of supply networks.

According to Goldsby and Martichenko (2005), the concept of supply chain management is not well understood or agreed upon. They affirm that much debate has surrounded the very meaning of the term, with lack of proper consensus existing even today. Even the functions that belong in supply chain management are in debate. Managing supply chains is also a difficult undertaking to achieve since it involves coordination of planning and operational activities throughout the company as well as coordination with the activities of suppliers, customers and information, hence the evolution of the concept of integrated supply chain management.

Supply chains integrate all those processes required to obtain and deliver products to customers. They are based on establishment of systematic relationships in which the supply chain partners align their strategies, share their relevant systems and data, coordinate their organisations, and cooperate in each other's operations (Bender, 1997). It is to be appreciated that, despite the risks associated with it, global supply chains continue to grow longer and more complex as companies push deeper into uncharted territories in search of lower costs (Bovet, 2005).

Kenya supplies about 38% of cut–flowers and bouquets to the world market. Of this 97% are exported to the European Union, which consume 50% of the world flowers. (HCDA, 2008). Major second tier markets are Netherlands, United Kingdom, Germany, France and other European Union countries. The balance, only 3%, is what is consumed locally. It is to be noted that the United States of America, Japan and the Middle East are coming up fast as significant markets, depending on development of infrastructure at destination point and direct transport.

Despite knowing all the benefits that accrue due to a well managed supply chain, it is only through leverage with advanced information technology that Kenya stands to gain more from the floriculture industry. What maybe called for is integration of all geographical areas associated in the global information network to enhance the end to end and within Kenya supply networks optimisation.

2.0 RESEARCH METHODOLOGY

In this paper the results of quantitative analysis of the data obtained from phase two of the research process is presented. A test of reliability of the measuring instruments was done using cronbach test followed principal component factor analysis using verimax rotation, first using eigenvalues greater than 1. A repeat of principal component analysis is then done to extract four factors followed by extraction of five factors.

The target population for quantitative process of the research was all the firms involved in active export of cut-flowers as per data obtained from HCDA. This included 412 firms and population sampling was used. This was quite possible because information is available on each firm's physical location and contacts which obtainable form HCDA. Table 1.1 is an illustration of the stratification of the floriculture industry in Kenya.

Table 1.1: Stratification of the floriculture industry in Kenya.

	INTERNATIONAL	**LOCAL**	**FREE**	**TOTAL**
LARGE	05	42	07	54
SME			358	358
TOTAL				**412**

(Source: Awuor, 2011)

This analysis shows that there are only five international players in this industry. The vast majority are local firms which are mainly small scale and most operating as free agents.

Data analysis involved use of component factor analysis (PCA) in an attempt to isolate the factors that are most significant in developing the conceptual model. This involved first undertaking factor analysis to extract variables with eigenvalues grater than 1.0 then doing subsequent factor analysis to extract four factors using eigenvalues grater than 0.490 in order to comply with the proposed conceptual model. This was folllowed by an extraction of five factors groupings in order to identify any significant factor that may not have been initially captured..

3.0 QUANTITATIVE DATA ANALYSIS

Principal component analysis (PCA) was used for extraction of the factors. Prior to performing PCA the suitability of data for factor analysis was assessed. Inspection of the correlation matrix revealed the presence of many coefficients of .3 and above. The Kaiser-Meyer-Oklin value was .961, exceeding the recommended value of .6 (Kaiser, 1970, 1974 in Pallant, 2005) and the Bartlett's Test of Sphericity reached statistical significance, supporting the factorability of the correlation matrix, this is as shown in table 1.1.

Table 1.1: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.961
Bartlett's Test of Sphericity	Approx. Chi-Square	34768.758
	df	1275
	Sig.	.000

(Source: Pallant, 2005)

Principal component analysis with verimax rotation using eigenvalues greater than 1.0 revealed fifteen factors as indicated in table 5.8. The fifteen factors are groupings generated from the research instrument which had 51 questions, herein indicated as variables VAR0001 to VAR0051. Reference to appendix H will show the particular question that each addressed. Appendix H addresses the link to quantitative data analysis from research instrument for phase two of the study. For example, VAR001 is linked to the question on position in the company, VAR002 linked to question on highest level of education all the way to VAROO51 which addresses the question on influence of legislation / governance on development of a conceptual model.

Table 1.2: Principal component analysis with verimax rotation reflecting factor loadings greater than 0.49

	Component														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
VAR00001															.688
VAR00002													.715		
VAR00003													.768		
VAR00004															-.761
VAR00005															
VAR00006			.883												
VAR00007			.938												
VAR00008			.922												
VAR00009			.868												
VAR00010															
VAR00011				.595											
VAR00012										.740					
VAR00013										.832					
VAR00014				.850											
VAR00015				.882											
VAR00016				.864											
VAR00017	.870														
VAR00018	.878														
VAR00019	.919														
VAR00020	.879														
VAR00021	.897														
VAR00022	.871														
VAR00023	.788														
VAR00024									.868						
VAR00025									.883						
VAR00026									.698						
VAR00027								.774							
VAR00028								.871							
VAR00029								.773							
VAR00030												.739			
VAR00031												.560			
VAR00032														.671	

VAR00033		.890													
VAR00034		.925													
VAR00035		.904													
VAR00036		.867													
VAR00037		.798													
VAR00038						.646									
VAR00039						.878									
VAR00040						.895									
VAR00041						.826									
VAR00042					.783										
VAR00043					.882										
VAR00044					.769										
VAR00045					.728										
VAR00046							.529								
VAR00047							.857								
VAR00048							.904								
VAR00049							.866								
VAR00050											.851				
VAR00051											.901				

A summary of the factors is shown in table 1.3. The variable addressing each factor is derived from the research instrument summarised in appendix H. In this case VAR0017 to VAR0023 formed factor 1; VAR0033 to VAR0037 formed factor 2; VAR006 to VAR009 formed factor three and this was generated to factor 15 which is formed primarily of VAR001 and VAR004.

Table 1.3: Description and summary of PCA factors solution

Variable	**Factor**
VAR00017– VAR00023	Factor 1: Financing
VAR00033 –VAR00037	Factor 2: Information integration
VAR0006- VAR0009	Factor 3: Transport
VAR00011, VAR00014 –VAR00016	Factor 4: Country specific benefits
VAR00042 – VAR00045	Factor 5: Key success factors
VAR00038 – VAR00041	Factor 6: Social audit
VAR00046 –VAR00049	Factor 7: Country development
VAR00027 – VAR00029	Factor 8: Warehouse management
VAR00024 –VAR00026	Factor 9: Internet access
VAR00011–VAR00013	Factor 10: Research and development
VAR00050– VAR00051	Factor 11: Government legislation
VAR00030–VAR00031	Factor 12: Customer responsiveness
VAR0002-VAR0003	Factor 13: Education status

VAR00032	Factor 14: Distribution management
VAR0001 –VAR0004	Factor 15: Organisation structure

The proposed conceptual framework identified four factors as shown in shown in table 1.4. The factors identified are: country specific benefits; end to end benefits; key success factors and constraints. The constraints form a negative factor in the model and are identified as: access to finance; information integration; and ability to integrate into the supply networks of large firms. This explains the reason for forcing principal component analysis to produce four factors with loadings greater than 0.49.

Table 1.4: Summary of main factors from proposed conceptual model

Factor	**Description**
Factor 1	**Key success factors** – country development, research and development, financing, operational cost, customer responsiveness and information integration.
Factor 2	**Country specific benefits-** environmental audit, social audit and financial audit.
Factor 3	**End to end benefits-** operational cost, financing, country development, research and development.
Factor 4	**Constraints-** access to finance information integration, ability to integrate into supply networks of large firms

Principal component analysis only forced for four factors with loadings higher than 0.490 revealed results outlined in table 1.5. This was in an attempt to raise the factors previously identified through analysis data captured in the phase one of the study. By performing PCA and having five factors extracted was in attempt to identify the presence of any significant factors left out in the proposed model.

Table 1.5: PCA with verimax rotation forced to four factors reflecting factor loadings greater than 0.4

	Component			
	1	2	3	4
VAR00001				
VAR00002				
VAR00003				
VAR00004				
VAR00005				
VAR00006			.563	
VAR00007			.564	
VAR00008			.621	-.504
VAR00009			.609	
VAR00010				
VAR00011				
VAR00012				
VAR00013				
VAR00014	.602			
VAR00015	.647			
VAR00016	.569			

VAR00017		.798		
VAR00018		.820		
VAR00019		.841		
VAR00020		.815		
VAR00021		.856		
VAR00022		.812		
VAR00023		.728		
VAR00024				
VAR00025				
VAR00026				
VAR00027				
VAR00028				
VAR00029				
VAR00030				
VAR00031				
VAR00032				
VAR00033	.560			-.502
VAR00034	.549			-.545
VAR00035				-.522
VAR00036	.546			-.500
VAR00037				
VAR00038				
VAR00039			.527	
VAR00040			.513	
VAR00041				
VAR00042				
VAR00043				
VAR00044	.498			
VAR00045				
VAR00046	.490			
VAR00047				
VAR00048	.569			
VAR00049	.531			
VAR00050				
VAR00051				

The result of PCA forced for four factors with loadings greater than 0.490 resulted in four factors being identified based on information provided by the research instrument on appendix H. For instance VAR0017 to VAR0023 formed a distinct grouping isolated as factor 2 whereas VAR006 to VAR009 and VAR0039 to VAR0040 also formed a distinct grouping isolated as factor 3.

Table 1.6: Description and summary of four factor solution

Variable	**Factor**
14-16, 33-34,36, 44,46, 48 – 49	Factor1: Key success factors
17 -23	Factor 2: Financing
6 – 9, 39-40	Factor 3: Transportation
8, 33 -36	Factor 4: Information integration

It was necessary to verify the model by forcing the extraction of a fifth factor, in which case the principal component analysis results produced are as shown in table 1.7. The resultant factors generated are summarized in table 1.8.

Table 1.7: PCA verimax rotation forced for five factors with loading greater than 0.49

	Component				
	1	2	3	4	5
VAR00001					
VAR00002					
VAR00003					
VAR00004					
VAR00005				.566	
VAR00006					.791
VAR00007					.830
VAR00008					.894
VAR00009					.831
VAR00010					
VAR00011					
VAR00012					.578
VAR00013					
VAR00014				.500	
VAR00015				.516	
VAR00016					
VAR00017	.848				
VAR00018	.867				
VAR00019	.921				
VAR00020	.893				
VAR00021	.895				

VAR00022	.877				
VAR00023	.770				
VAR00024				.595	
VAR00025				.597	
VAR00026					
VAR00027					
VAR00028				.607	
VAR00029				.690	
VAR00030				.575	
VAR00031				.546	
VAR00032					
VAR00033			.835		
VAR00034			.868		
VAR00035			.835		
VAR00036			.802		
VAR00037			.730		
VAR00038					
VAR00039					
VAR00040					
VAR00041					
VAR00042		.596			
VAR00043		.688			
VAR00044		.737			
VAR00045		.682			
VAR00046		.705			
VAR00047		.698			
VAR00048		.744			
VAR00049		.685			
VAR00050					
VAR00051					

A summary of the variables with the introduction of the fifth factor identified as illustrated in table 1.8 include; air freight cost, air freight reliability, energy cost, road infrastructure and research and development as a completely separate factor. These points out the need to adequately invest in transportation, research and development to enhance performance of the industry. With reference to the proposed conceptual model and the set of questions used for the quantitative data analysis as outlined in annex 1. The following observations were made which resulted in identification and naming of the factors in the revised conceptual model.

Table 1.8: Description and summary of five factor solution

Variable	**Factor description**
VAR00017–VAR00023: market share, return on investment, growth of market share, growth of sales, growth on investments, profit on sales and overall competitive position	**Factor 1**: Financing
VAR00042–VAR00049: influence of country development, quality of inputs, finance, research, customer responsiveness, environmental audit, financial audit and social audit.	**Factor 2**: Key success factors
VAR00033 – VAR00037: information sharing, proprietary partner informed of changing needs, trading partners keep company fully informed.	**Factor 3:** Information integration
VAR0005, VAR00014-15, VAR00024-25, VAR00028-31: workforce in the company, environmental audit, social audit, company use of intranet and extranet, company use of various information technology software.	**Factor 4**: Country specific benefits
VAR0006 -9, VAR00012: air freight cost, airfreight reliability, energy cost, road infrastructure, research and development	**Factor 5:** Transport, Research and development

3.1 Revised proposed conceptual model

The results of principal component analysis with five extractions resulted in a revision of the conceptual model to include: financing; key success factor; country specific benefits, transport, research and development as positively influencing the performance of the floriculture industry in Kenya. The revised conceptual model is illustrated in fig 1.1.

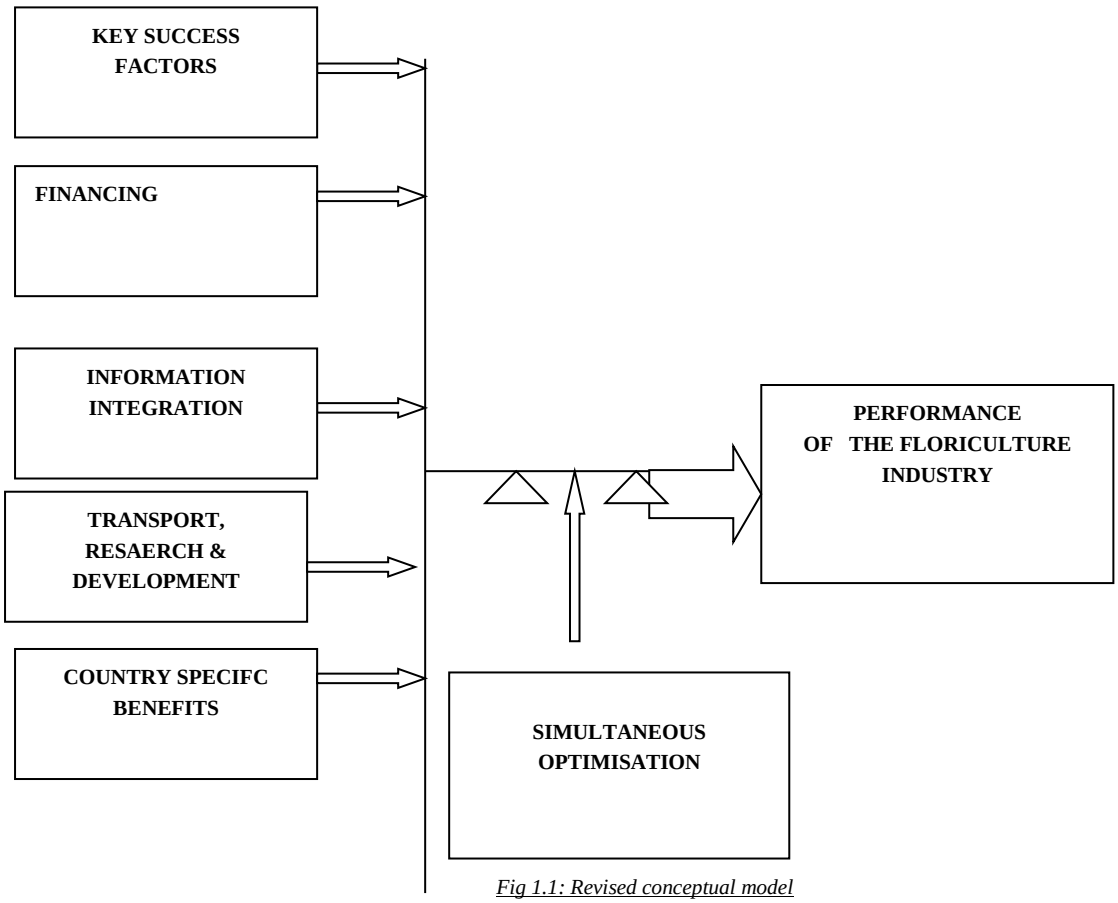

Fig 1.1: Revised conceptual model

4.0 CONCLUSION

This paper presented the results of the quantitative data analysis which resulted in the revision of the conceptual model for managing supply networks for simultaneous optimisation. Factor analysis was used after confirmation through Kaiser –Meyer –Value and Bartlett's test that the data available is suitable for analysis. Principal component analysis of factors with eigenvalues more than 1.0 identified 15 factors and a further analysis using eigenvalues greater than 0.490 identified four factors thus conforming to the initial proposed conceptual model. However, extractions of five factors still with PCA lead to the identification of a fifth factor composed of: air freight cost; air freight reliability; energy cost; road infrastructure; research and development. This resulted in the revision of the conceptual model.

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Horticultural Crops Development Authority (HCDA) web site: http://www.hcda.org

ANNEX 1

LINKAGE OF PRINCIPAL COMPONENT ANALYSIS TO RESEARCH INSTRUMENT.

Variable	Question link
VAR0001	Position in the company
VAR0002	Highest level of education
VAR0003	Period in the company
VAR0004	Position in the organisational hierarchy
VAR0005	Total workforce in the firm
VAR0006	Air freight cost
VAR0007	Air freight reliability
VAR0008	Energy cost
VAR0009	Road infrastructure
VAR00010	Cold chain facilities
VAR00011	Cargo handling
VAR00012	Research and development
VAR00013	Governance / legislation
VAR00014	Environmental audit
VAR00015	Social audit
VAR00016	Financial audit
VAR00017	Market share
VAR00018	Return on investment
VAR00019	The growth of market share
VAR00020	The growth of sales
VAR00021	Growth in return on investment

VAR00022	Profit margin on sales
VAR00023	Overall competitive position
VAR00024	Company use of intranet
VAR00025	Company use of extranet
VAR00026	Company use of internet
VAR00027	Company use of electronic fund transfer
VAR00028	Company use of inventory management systems
VAR00029	Company use of warehouse data management system
VAR00030	Company use of electronic system to facilitate relations with customers
VAR00031	Company uses IT to send documents online (EDI)
VAR00032	Company uses electronic system to facilitate relations with distributors
VAR00033	Information sharing with proprietary partner
VAR00034	Proprietary partner informed of changing needs in advance
VAR00035	Trading partners keep company fully informed of issues
VAR00036	Trading partner shares information with company
VAR00037	Trading partner keeps company fully informed about issues
VAR00038	Extent to which floriculture industry cause environmental degradation
VAR00039	Effect of industry on health
VAR00040	Effect of industry on productivity
VAR00041	Effect of industry on social conditions
VAR00042	Influence of country development on dev't of conceptual model
VAR00043	Influence of quality of inputs on dev't of conceptual model
VAR00044	Influence of financing on dev't of conceptual model
VAR00045	Influence of R&D on dev't of conceptual model
VAR00046	Influence of customer responsiveness on dev't of conceptual model
VAR00047	Influence of environmental audit on dev't of conceptual model
VAR00048	Influence of financial audit on development of conceptual model
VAR00049	Influence of social audit on dev't of conceptual model
VAR00050	Influence of currency exchange rate on deve't of conceptual model
VAR00051	Influence legislation/governance on dev't of conceptual model