Factor analysis of the market environment for artisanal dimension stone in Nairobi, Kenya

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Abstract: Artisanal dimension stone (i.e., blocks cut and shaped from natural rock using hand tools) has attracted scholarly attention as part of the informal sector of the construction industry and as part of the productive enterprise of artisans. One of the areas that intrigue scholars in this respect is the market environment of the subject product. In Nairobi, for instance, researchers have adopted a qualitative approach to the study of the market environment of artisanal dimension stone. We build on the outcomes of previous studies to present a quantitative approach to the factors influencing the market environment of artisanal dimension stone in Kenya by developing the factors identified in the past studies into 24 measurable variables that are then subjected to factor analysis to identify and gauge the principal components. The analysis identifies five principal components that influence the market environment: a difficult marketing terrain, a general lack of specification by building professionals and formal developers, occasional specification by building professionals, a cumbersome stone procurement system, and advantages provided by the use of artisanal dimension stone in building. These include both negative and positive factors, although the negative forces tend to dominate, resulting in an inhibitive rather than a facilitative environment. Recommendations are made to address this situation, including recommendations for an association with Communities and Small-Scale Mining (CASM) (a mining advocacy organisation) or similar institution and the formation of a marketing cooperative by the producing units to help in the formalisation of their transactions.

Keywords: Artisanal dimension stone, Factor analysis, Marketing, Nairobi

INTRODUCTION

Dimension stone refers to rock that has been cut and worked to a specific size or shape for use in building construction (Ashurst and Dimes, 1977). There are different types of dimension stone that may be used in the building envelope, including tiles for roofing, tiles or slab stone for floor finish, tiles (e.g., marble) for wall finish and blocks for stone masonry. The focus of this study is on stone masonry, also known as "cut stone" or "ashlar" (Hornsbostel, 1991). In this context, dimension stone takes the meaning attributed to it by Prentice (1990) as pieces of stone that have been cut into regular (three) dimensions and used for wall construction.

Shadmon (1989: 58) noted that there are two categories of tools used in extracting and working (manufacturing) dimension stone, i.e., hand tools or machine tools. Adopting the definition of artisanal materials by Wells and Wall (2003) as materials produced by individuals who use methods based on hand tools with simple division of labour and little capital equipment, artisanal dimension stone refers to materials produced using the first category of tools — building stones of regular dimensions that have been extracted and worked using hand tools as opposed to machine tools.

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According to Ofori (2000), the development of the construction industry is necessary for developing countries to fulfil their role of sustaining national economic and social development. Some areas that require research and development in this case include materials and the informal sector (Ofori, 2000). Therefore, research on artisanal dimension stone will contribute substantially to the development of the construction industry in Nairobi, Kenya in particular and the developing world in general.

Materials are the largest component of building construction unit costs (Kenya Building Research Centre, 2006). Hence, a study involving material marketing distribution and use is of great significance for the housing market in Nairobi. Nevertheless, the factors involved and the processes used in this study may also apply in the general contexts of artisanal mining and the market environment.

This study is arranged in five parts. The first part presents a review of the literature on dimension stone within the context of the research that has been conducted on the quarrying of artisanal dimension in Nairobi. The next two parts present the analysis technique and the methods of data generation. The last two parts present the analysis results and discussion.

ARTISANAL QUARRYING OF DIMENSION STONE IN NAIROBI

Quarrying is a form of mining distinguished by the fact that the product is intended for construction or architectural purposes, rather than for other human uses (Lahiri-Dutt, 2004). Artisanal dimension stone has been the subject of research in Kenya within studies initiated by the Intermediate Technology Development Group (ITDG) (see Wells, 2000). Wells (2000) is mainly concerned with the environmental impacts of artisanal stone mining in Nairobi, having undertaken research on the environmental impact of artisanal stone quarrying in Kenya. This research was funded by the UK Department for International Development through the ITDG, now known as Practical Action. Published in the *Small Enterprises Development* journal, the paper aptly situates quarrying of artisanal dimension stone in Nairobi in the context of small enterprises that contribute to employment creation and provision of basic goods at low cost (Wells, 2000). Although the paper makes some points about the business environment for the production of artisanal dimension stone in Nairobi, its main focus is on the ecological environment.

In a related paper, Wells and Wall (2003), consider artisanal materials in East African cities, specifically sawn timber in Dar es Salam and dimension stone in Nairobi. This study situates production of artisanal materials in the informal sector context or "the informal construction industry" (Wells, 2001; 2007). According to the paper, the production of artisanal dimension stone is greatly influenced by factors related to the liberalisation and eventual *informalisation* of the building industry. Liberalisation of the economy brought about the deregulation of cement prices, which led to a sharp increase in cement prices. The increase in cement prices led in turn to a rise in the cost of the main competing wall material, i.e., concrete blocks, of which cement is a significant component, thereby ceding part of its market to dimension stone.

Wells and Wall (2003) also contend that economic liberalisation led to a shift in building activities from the public to the private sector, especially to informal developers who generally build incrementally and therefore purchase materials such as stone in small quantities. Artisanal producers of stone are better positioned to fill small and regular orders than they are to fill large and intermittent orders from public-sector or large-scale private developers. Private developers in the informal sector also tend to be less particular about the standard of finish than public-sector or large-scale developers in the formal sector, who tend to adhere to the rigour of standards. They therefore tend to favour artisanal dimension stone over machine-cut dimension stone or factory-produced concrete blocks.

Despite the facilitating factors discussed above, artisanal stone as a product remains hampered and may not penetrate the formal sector market because of the inherent inability of artisans to produce large quantities of stone on short notice, given that artisanal production techniques are generally labour-intensive and slow. Secondly, artisanal producers generally operate at a subsistence level; hence, capital limitations prevent them from stockpiling stone for large-scale orders.

Wells and Wall (2003) identified some of the issues affecting the marketing of artisanal dimension stone in Nairobi. These issues were studied further by K'Akumu, Jones and Blyth (2010), who examined the marketing channels of artisanal dimension stone and documented the interactions of the actors involved, including producers, competitors (producers of alternative materials), consumers (developers/builders) and their agents (architects, quantity surveyors, engineers and other professionals who may specify products on behalf of developers), intermediaries (e.g., transporters, stockists and brokers) and regulators (e.g., the City Council of Nairobi, the National Environment Management Authority, and the Department of Geology).

K'Akumu, Jones and Blyth (2010) noted several issues concerning the product. For instance, stone marketing follows a pull strategy according to which a handicapped producer lacks the capacity to push the product to the market. The transactions involved in informal systems are characterised by unconventional exchange relationships. Like Wells and Wall (2003), they noted that dimension stone is mainly used in the informal sector but has high potential for use in the formal sector. Lastly, they noted the potential for micro-enterprise development, including micro-finance and micro-investments that can support urban livelihoods.

K'Akumu, Jones and Blyth (2010) also noted the major factors in the market environment that enhance or hinder the use of artisanal dimension stone in Nairobi. These included the Building Code, implemented through a plan approval process that only allows the use of stone, brick or block. The main hindrance is the lack of policy support from the central and local governments; marketing was observed to rely on poor infrastructure, e.g., roads.

From the foregoing discussion, it becomes apparent that researchers have sought to identify the factors and forces that influence the marketing of artisanal dimension stone in Nairobi. However, the research output for Nairobi is not supported by any statistical evidence. For instance, K'Akumu, Jones and Blyth (2010) relied on ethnographic methods to identify these factors. Therefore, the current paper goes a step further to identify the factors that influence the market environment of artisanal using a quantitative technique — factor analysis. The factors suggested from the artisanal mining literature and artisanal stone quarrying literature in Nairobi are synthesised into 24 variables (indicators) for consideration in factor analysis, as explained in the section on "The Methods of Data Generation".

THE FACTOR ANALYSIS TECHNIQUE

According to Brown (2006: 12–13) the fundamental intent of factor analysis "is to determine the number and nature of latent variables or factors that account for the variation and co-variation among a set of observed measures, commonly referred to as indicators". A factor in this case is "an unobservable variable that influences more than one observed measure and that accounts for the correlations among these observed measures" (Brown, 2006: 13). Factor analysis involves analysing the structure of covariance and correlation matrices (see Lawley and Maxwell, 1971: 3; Brown, 2006: 17).

Exploratory factor analysis (EFA) was found to be ideal for this research topic, which matches the description given by Kline (1994: 10), i.e., a situation "where data are complex and it is uncertain what the most important variables in the field are". Brown (2006) described EFA as a "data-driven" approach involving no a priori specifications of the number of latent factors or the pattern of relationships between the common factors and the observed variables. Therefore, in this context, EFA is employed as an exploratory and descriptive technique to determine the appropriate number of common factors and to determine which measured/observed variables are reasonable indicators of the various latent dimensions (see Brown, 2006: 14). Accordingly, the overriding objective of EFA, based on the observations of Brown (2006), is to evaluate the dimensionality of a set of multiple indicators (e.g., items addressed in a questionnaire) by identifying the smallest number of interpretable factors needed to explain the correlations among them.

Principal component analysis (PCA) was used to generate the interpretable factors. According to Fox and Skitmore (2007), PCA successively extracts factors based on the maximum variance between the variables. The first factor extracted accounts for the largest amount of variance in the variables. The second factor extracted accounts for the next largest amount of variance that is not related to or explained by the first factor, meaning that the two factors are not related to one another (i.e., they are orthogonal) (Bryman and Cramer, 1997). The third factor extracted accounts for the next largest amount of variance and so on. The first few factors therefore form the principal components (most important factors) at the end of the factor extraction.

This study relied on two main statistical measures as the basis of its conclusions: Eigenvalues and the total variance explained. Thompson (2004: 21) defined Eigenvalues as "a set of squared area-world statistics [...] also known as characteristic roots". Eigenvalues are useful in factor analysis as deciding criteria as to what are the most important factors to be considered in the analysis. The default position in making a decision about the number of factors to consider in statistical analysis is the "Eigenvalue greater than 1.0 rule". The logic of this rule follows the Guttman argument of 1954 that noteworthy factors should have Eigenvalues greater than 1.0 (Thompson, 2004). Nevertheless, researchers should exercise judgement when applying the "Eigenvalue greater than 1.0 rule" in determining the number of factors to consider because Eigenvalues, like all sample statistics, entail some sampling error (Thompson, 2004). For purposes of analytical comparison, the *screen test* and *parallel analysis* were applied in deciding on the number of factors to retain.

THE METHOD OF DATA GENERATION

From the literature review, 24 variables (see the full list at the bottom of Figure 1) with the potential to influence the marketing environment of artisanal dimension stone were identified. These variables were developed into prompts in the measurement instrument. The instrument consisted of a questionnaire administered by a researcher to respondents on a face-to-face basis. The respondents were asked the following two-part question corresponding to the marketing environment: Can you tell me what helps or hinders artisans in selling or distributing artisanal dimension stone? (The underlying idea was to establish the opportunities and constraints that exist for artisans in the marketing of artisanal dimension stone).

The 24 variables were listed as prompts under the question, and the respondents were further prompted to indicate for each variable whether it was a negative (hindering) or positive (facilitating) influence. Because the respondents were not expected to have complete knowledge of the factors prevailing in the market environment, they were given a third option to indicate that they were unable to comment (or had no opinion) on the variable under consideration.

For purposes of scale development, in cases in which the respondents had opinions about certain variable, they were prompted to indicate the strength of each variable's influence on a scale of 1–5 where 1 represented the least influence and 5 represented the greatest influence. This yielded a total of 11 possible responses: five negative, five positive and one neutral. In the final coding for the SPSS dataset, the responses were re-coded into an 11-point Likert scale as follows:

Initial Code	Re-Code	Scaled Code
Negative 5	Negative strongest	1
Negative 4	Negative strong	2
Negative 3	Negative average	3
Negative 2	Negative weak	4
Negative 1	Negative weakest	5
Unable/no opinion	Neutral	6
Positive 1	Positive weakest	7
Positive 2	Positive weak	8
Positive 3	Positive average	9
Positive 4	Positive strong	10
Positive 5	Positive strongest	11

The dataset generated was then used in the factor analysis.

After the measurement instrument was designed, it was administered according to an interview schedule to a sample of respondents who included practicing architects; quantity surveyors; civil and construction engineers; building contractors in categories A, B and C; and quarry operators. Prospective respondents were identified from lists of registered and practicing professionals from their respective boards of registration, i.e., the Board of Registration of

Architects and Quantity Surveyors (BORAQS), the Engineers Registration Board (ERB) and the Registration of Contractors Secretariat within the Ministry of Public Works. The lists obtained from the professional registration bodies were cleaned by isolating the target professional categories and eliminating those who did not operate within the Nairobi business environment. The list was then numbered to form a sampling frame. This was successfully conducted for practicing architects, practicing quantity surveyors and practicing building contractors in categories A, B and C. Determination of the sampling frame for practicing civil and construction engineers in Nairobi was impossible because the ERB registers all types and published a list of engineers without categorising them as electrical, mechanical, civil and construction, etc. After determining the target sample size for each stratum of respondents, the sample was drawn from a numbered list (sample frame), using a universal random sampling table.

Compiling a list of the informal quarry operators entailed potentially serious dangers as the researchers could not go into the quarries and begin to ask about details of quarry operations without raising suspicions and facing a lack of cooperation. The researchers learned that quarries may be temporary hideouts for criminals, and attempts to establish the identities of people may not be welcome. Therefore, given this type of difficulty and the financial and time limitations, the researchers decided on an absolute sample size of 40. This sample was distributed to the four quarrying clusters that were operational at the time of data collection: Ngong (Oloolua), Kenya Quarries, Kwa Hinga and Njiru. On these sites, the first ten operators who agreed to respond were interviewed using the interview schedule. Two other non-building professionals were interviewed to bring the total number of respondents to 148, as shown in Table 1.

To ensure the suitability and reliability of the data for factor analysis, an adequate sample size was needed. There are various suggestions on the most suitable sample size for factor analysis. Hinton et al. (2004) and Pallant (2007), for instance, recommended a minimum ratio of two subjects (respondents) for every one item (variable). However, to ensure that the data met the sample size threshold for factor analysis, the researchers relied on the suggestion by Gorsuch (1983), popularly cited in factor analysis literature (see, for example, MacCallum et al., 1999; Khalid, n.d.; Velicer and Fava, 1998; Guadagnoli and Velicer, 1988; MacCallum et al., 2001; Ledakis, 1999; Osborne and Costello, 2004; Pearson, 2008), of an absolute minimum ratio of five respondents to every variable and not less than 100 respondents for any analysis. The ratio of 148 respondents to 24 variables is 6.16 (>5) and exceeds the threshold for the minimum number of respondents (100). Having fulfilled Gorsuch's conditions, the data were subjected to factor analysis. The results obtained are described in the following section.

Table 1. Sample Size for Professional Respondents

Professionals	Number Practicing	Calculated Sample Size	Targeted Sample Size	Actual Sample size
Architects	198	31	35	35
Quantity surveyors	134	29	32	32
Civil and construction engineers	–	–	–	6
Building contractors;				
Category A	57	22	23	14
Category B	18	12	13	13
Category C	51	21	22	6
Total	**458**	**121**	**125**	**106**

RESULTS

In addition to the suggestions by Gorsuch (1983), before embarking on the factor analysis, the data were assessed for suitability for factor analysis using the Kaiser–Meyer–Olkin Measure of Sampling Adequacy (KMO) and Bartlett's Test of Sphericity. The latter establishes whether there are relationships to investigate (Hinton et al., 2004). The KMO value should be .6 or more while the sig value should be .5 or less (Pallant, 2007; Hinton et al., 2004). As shown in Table 2, in this case, the KMO value is .661 while the sig value is .000; hence, the data passed these test and were considered appropriate for use in factor analysis.

Table 2. KMO and Bartlett's Test

Kaiser–Meyer–Olkin Measure of Sampling Adequacy		.661
Bartlett's Test of Sphericity	Approx. Chi-Square	1441.606
	df	276.000
	Sig.	.000

The analysis proceeded to factor extraction, which yielded seven components generated by the default Kaiser criterion, as shown in Table 3. A scree plot for the components was also generated, as shown in Figure 1. The scree plot tends to conform to the results of the Kaiser criterion of seven components. This is clearly visible in Figure 1, in which the slope of the graph tends to even out after component 7.

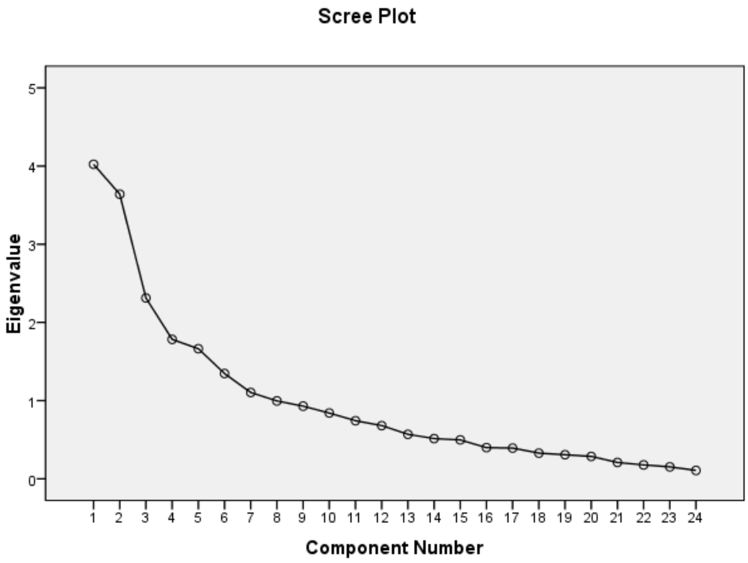

Figure 1. Initial Scree Plot

Component identities are as follow:

1. Specified by quantity surveyors
2. Not specified by quantity surveyors
3. Specified by structural engineers
4. Not specified by structural engineers
5. Specified by architects
6. Not specified by architects
7. Specified by formal developers/clients
8. Not specified by formal developers/clients
9. Decisions by informal developers
10. Specified by informal designers
11. Decisions by stockists to stock
12. Brokers procures directly for customer
13. Availability of transportation
14. Costs of transportation
15. Quality of infrastructure (roads)
16. Poor health and safety practices effect production
17. Formal clients do not use jua kali dimension stone because of legal difficulties
18. Competitors' practices limit the demand for jua kali dimension stone
19. Dimension stone used due to security it gives building
20. Dimension stone is used because designers know how to use it
21. Unethical practices in jua kali dimension stone mining reduces demand
22. Dimension stone used historically
23. Dimension stone used due to durability
24. Dimension stone is used because builders know how to use it

The next step was to make a decision about how many factors should be retained in the analysis, using the Monte Carlo PCA for parallel analysis.

Table 3. Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	4.022	16.760	16.760	4.022	16.760	16.760	2.722
2	3.639	15.165	31.924	3.639	15.165	31.924	3.429
3	2.312	9.635	41.559	2.312	9.635	41.559	2.616
4	1.783	7.431	48.990	1.783	7.431	48.990	1.776
5	1.664	6.932	55.922	1.664	6.932	55.922	3.013
6	1.346	5.610	61.532	1.346	5.610	61.532	2.069
7	1.103	4.598	66.130	1.103	4.598	66.130	1.693
8	.996	4.149	70.279				
9	.929	3.871	74.149				
10	.841	3.504	77.653				
11	.743	3.095	80.748				
12	.680	2.834	83.582				
13	.569	2.370	85.952				
14	.515	2.144	88.096				
15	.497	2.073	90.169				
16	.399	1.662	91.831				
17	.393	1.636	93.467				
18	.328	1.368	94.834				
19	.308	1.283	96.118				
20	.286	1.192	97.310				
21	.209	.871	98.181				
22	.177	.739	98.920				
23	.153	.635	99.555				
24	.107	.445	100.000				

Extraction Method: Principal Component Analysis

Notes:
a. When components are correlated, the sums of squared loadings cannot be added to obtain a total variance.

A comparison of the default Kaiser Criterion with the parallel analysis Eigenvalues led to the retention of six of the seven initial components, as shown in Table 4.

Table 4. Comparison of Eigenvalues from SPSS and Monte Carlo Outputs

Component	Actual Eigenvalues from SPSS	Random Eigenvalue from Monte Carlo	Decision
1	4.022	1.8110	Accept
2	3.369	1.6728	Accept
3	2.312	1.5796	Accept
4	1.783	1.4816	Accept
5	1.664	1.4019	Accept
6	1.346	1.3275	Accept
7	1.103	1.2641	Reject

Another factor analysis was conducted with the number of components restricted to six. The output of this second analysis included the component correlation matrix (Table 5) and the pattern matrix (Table 6). The component correlation matrix indicates that the components are not correlated because the correlation coefficients exhibited are far less than 0.3.

Table 5. Component Correlation Matrix

Component	1	2	3	4	5	6
1	1.000	.151	.000	.000	–.161	.006
2	.151	1.000	.111	–.109	–.001	.023
3	.000	.111	1.000	–.050	.155	–.133
4	.000	–.109	–.050	1.000	.018	–.077
5	–.161	–.001	.155	.018	1.000	–.122
6	.006	.023	–.133	–.077	–.122	1.000

Extraction Method: Principal Component Analysis
Rotation Method: Oblimin with Kaiser Normalisation

On the other hand, the pattern matrix was used to interpret the analysis because it indicates how variables load onto the extracted components.

Table 6. Pattern Matrix[a]

	Component					
	1	**2**	**3**	**4**	**5**	**6**
Quality of infrastructure (roads)	.842	–.346				
Competitors' practices limit the demand of jua kali dimension stone	.668					.352
Cost of transportation	.571					
Dimension stone used historically	–.511					–.429
Formal clients do not use jua kali dimension stone because of legal difficulties	.480					
Not specified by architects		.867				
Not specified by structural engineers		.800				
Not specified by quantity surveyors		.715				
Not specified by formal developers/clients		.659				
Poor health and safety practices affect production		.511	.301	.330		
Decision by stockists to stock		.431	.383			
Specified by architects			.752			
Specified by structural engineers			.605			
Decisions by informal developers			.599			
Unethical practices in jua dimension stone mining reduces demand			–.580	.311		–.306
Specified by formal developers/clients	.415		.457			
Brokers procure directly for customers				.789		
Availability of transportation				.752		
Dimension stone is used because designers know how to use it					.829	
Dimension stone is used because builders know how to use it					.826	.346
Dimension stone used due to security it gives building					.718	–.323
Dimension stone is used due to durability					.665	–.467
Specified by informal designers						–.636
Specified by quantity surveyors				.385		–.576

Extraction Method: Principal Component Analysis
Rotation Method: Oblimin with Kaiser Normalisation

Notes:
a. Rotation converged in 33 iterations.

From the pattern matrix, the following conclusions were drawn:

1. Component 1 is the difficult marketing terrain.
2. Component 2 is a general lack of specifications by building professionals and formal developers.
3. Component 3 is occasional specification by building professionals.
4. Component 4 is a cumbersome stone procurement system.
5. Component 5 is advantages provided in the use of artisanal dimension stone in building.
6. However, Component 6 proved indistinct and could not be identified.

DISCUSSION

The results of the factor analysis presented in Table 6 show that the first factor in the market environment is the difficult marketing terrain. In factor analysis, the first component is usually general in nature. The variable loadings on this factor include the following:

1. Quality of infrastructure (roads)
2. Competitors' practices limiting the demand for jua kali dimension stone
3. Cost of transportation
4. Formal clients not using jua kali dimension stone because of legal difficulties

The variables can be associated with negative aspects of the market environment. It becomes apparent from the factor loadings that the main challenge to the marketing of artisanal dimension stone is the poor state of the roads leading to the quarries or providing outlets for the quarry operators' product. This is tied to the cost of transportation, which is implied by poor roads. The other factor is the advantage that competitors' products have over artisanal dimension stone. Lastly, the inability of formal customers to transact with artisanal producers because the latter rely on informal exchange relations (see K'Akumu, Jones and Blyth, 2010) is another important factor loading onto this component.

It is important to note that although this factor is general in nature, its solution lies in the improvement of the transportation infrastructure, the need to make artisanal products more competitive in the market and the need to establish formal legal transactions in place of informal exchanges. Artisanal dimension stone would be made more competitive in the market if the transport problems were solved; this would lower its price and thereby increase its competitiveness and improve sales volumes. Secondly, the establishment of formal legal transactions would attract more formal customers. As discussed later, one of the ways of establishing a formal legal system of transactions is by the operators initiating a cooperative. A marketing cooperative would be a corporate body with formal status that could legally transact business with formal end users of artisanal dimension stone or their representatives.

The second factor in the market environment is the general lack of specifications by building professionals and formal developers. The variables that loaded onto this factor are the following:

1. Not specified by architects
2. Not specified by structural engineers
3. Not specified by quantity surveyors
4. Not specified by formal developers/clients
5. Poor health and safety practices affect production
6. Decisions by stockists to stock

This too is a negative factor in the market environment, as demonstrated by the variables. Developing an environment for formal legal business transactions would make it easy for end users and their intermediaries to purchase more artisanal dimension stone.

Secondly, the problem with artisanal dimension stone is that it roughly conforms to standard width and breadth dimensions but has no standard length. Hence, length is measured per foot-run. This means one cannot count the number of stones, as is possible with other products, using three standard dimensions. Rather, one must measure the foot-run for purposes of quantification. The discontinuation of blasting and the application of benching techniques, which has been suggested by Wells (2000), could yield standard dimensions that would make it easy to quantify artisanal dimension stone in the same way as for machine-cut stone, concrete block and clay brick.

The third factor in the market environment is potential and occasional specification by formal actors and actual specification by informal actors in the building industry. The variables loading onto this factor are the following:

1. Poor health and safety practices affect production
2. Decision by stockists to stock
3. Specified by architects
4. Specified by structural engineers
5. Decisions by informal developers
6. Specified by formal developers/clients

This factor represents a positive force in the market for artisanal dimension stone. This positive aspect of the market could be promoted through social marketing, as discussed by K'Akumu, Jones and Blyth (2010).

The fourth factor in the market environment is a cumbersome stone procurement system. The variables that loaded onto this factor included the following:

1. Poor health and safety practices affect production
2. Unethical practices in jua dimension stone mining reduces demand
3. Brokers procure directly for customers
4. Availability of transportation
5. Specified by quantity surveyors

This is a negative force in the market for artisanal dimension stone in Nairobi. These results are consistent with the findings of the exploratory study reported by K'Akumu, Jones and Blyth (2010). With respect to exchange relationships within the marketing channels, the exploratory study found that the quarry operators lacked enough cash to buy their own means of transportation. Secondly, they could not market their products through the "push strategy". Instead, they had to rely on the "pull strategy" that involved customers or their intermediaries coming to purchase the products. Therefore, especially from the perspective of the producers, factor analysis confirms the findings of the exploratory study concerning stone procurement. This point is a subset of the first factor, difficult marketing terrain. As noted earlier, the first component or factor is usually a general one. However, some of the solutions proposed for the first factor, such as the formation of a marketing cooperative, may also be useful in addressing a cumbersome stone procurement system.

It is important to note that the variable *Poor health and safety practices affect production* loads on the preceding and the current principal component and yet the two components have contradictory influences on the market. This inconsistency, the only one identified in this study, may demonstrate that the variable was not properly conceived by the researchers and hence not properly evaluated by the respondents. Therefore, the variable was ignored in the interpretation/identification process because ignoring it does not compromise the main conclusions of the study.

The fifth factor is the advantages provided in the use of artisanal dimension stone in building. The variables that loaded onto this factor included the following:

1. Dimension stone is used because designers know how to use it
2. Dimension stone is used because builders know how to use it
3. Dimension stone used due to security it gives building
4. Dimension stone is used due to durability

This factor represents a positive force in the market for artisanal dimension stone in Nairobi. Again, this confirms the findings of the exploratory study (K'Akumu, Jones and Blyth, 2010), in which it was found that the Building Code and the Public Health Act specify the use of stone as wall material in building construction within the city because of its durability and weather exclusion properties. Therefore, this is an opportunity that artisanal producing units have to take full advantage of by improving their production and marketing systems, as suggested in the foregoing discussion.

The principal components have been identified and discussed in detail, but their relative strengths or degrees of influence have not been discussed. Therefore, the following discussion considers the relative strengths of the principal components and their implications for the market environment.

As explained previously, the PCA successively extracts factors based on the maximum variance between the variables. For instance, the first factor extracted accounts for the largest amount of variance in the variables, the second factor extracted accounts for the next largest amount of variance that is not related to or explained by the first factor (meaning that the two factors are orthogonal, or unrelated, to one another) and so on. Through the statistical analysis, the variances were found to be explained through factor analysis as shown in Table 3. It emerged that the first seven components contributed 66.1% of the total variance. However, component 7 was dropped from the analysis through the Monte Carlo process, while component 6 was indistinct. This left components 1–5, which explained 55.9% of the total variance. The information from Table 3 was used to construct Table 7.

Both the Eigenvalues and the percentages of the total variance explained indicate the magnitude or relative strength of each factor within the market environment. According to Table 7, the constraints explain more variance than opportunities, i.e., 39.4% (total for difficult marketing terrain, general lack of specification, and cumbersome stone procurement). Positive factors or opportunities explain only 16.5%, yielding a total of 55.9% of the variance being explainable by the principal components. Therefore, it is imperative to note that the market environment for artisanal dimension stone in Nairobi is dominated by hindering rather than facilitating factors or forces.

Table 7. Eigenvalues for and Total Variance Explained by Retained Factors

Type	Factor	Eigenvalues	Total Variance Explained (%)
Constraints	Difficult marketing terrain	4.022	16.8
	General lack of specification	3.639	15.2
	Cumbersome stone procurement system	1.783	7.4
	Sub-total	9.444	39.4
Opportunities	Occasional specification	2.312	9.6
	Advantages provided by stone material	1.664	6.9
	Sub-total	3.976	16.5
	Total	13.42	55.9
	Maximum	24.00	100.00

CONCLUSIONS AND RECOMMENDATIONS

As Table 9 shows, the analyses of the Eigenvalues for and total variance explained by the factors retained lead to the rational conclusion that the market environment analysed is dominated by hindering rather than facilitating forces. Therefore, having identified the principal components and measured their magnitude of influence, certain recommendations may be made regarding the market environment for artisanal dimension stone in Nairobi. In this context, there are two key steps that, if taken by the artisanal units, will help to address many of the problems they face in moving their products. These two steps are the following:

1. Formation of an association that would participate in CASM at the national or international level, and

2. Formation of a marketing cooperative to help in the sales and marketing of their product.

Formation of a CASM-like (Communities and Small-scale Mining, a worldwide network for small-scale miners sponsored by the World Bank) organisation would help the unit operators achieve a milestone in the area of governance of artisanal quarrying activities. This would also give them a stronger voice to negotiate with government bodies concerning policies, which would enhance their welfare in the economy. It would also open up opportunities for empowerment through association with non-governmental organisations that may provide assistance in terms of training, market research and development, and advocacy. This would help in reducing the obstacles that exist in the policy environment.

The formation of a marketing cooperative, on the other hand, would help with formal transactions that previously have not been possible, which has denied artisanal stone producers a good share of the formal sector of the market. Formalisation of market transactions will not only help in expanding the market but also will help small producers to pool their products together and hence be able to supply larger orders than they are currently able to supply.

Nevertheless, it is important to note that factor analysis, like any other analytical tool, has its limitations. One weakness that has been observed in this case concerns the extraction of a first factor that is usually too general and tends to be meaningless. We have also observed cases of one principal factor being indistinct and unidentifiable even though it had passed the retention test. This brings us to the point that although factor analysis is a quantitative technique, the process of identifying the principal components is interpretative, which in the end renders it a qualitative analysis. It is therefore no wonder that certain factors may be misplaced. An example is the case of the variable *Poor health and safety practices affect production*, which loaded on opposing principal components.

Lastly, dimension stone is only one artisanal material; there are several other types of artisanal materials used in building construction, such as bricks, blocks, and ballast. Further studies should be conducted to examine how the marketing environments for these materials compare to that of dimension stone.

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