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Application of Kraljic's purchasing portfolio matrix in construction industry – A case study

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Abstract

The Kraljic matrix has been largely used in many different industries as an efficient tool for developing differentiated purchasing strategies. However, its application on construction industry is unknown, as well as the lack of systematical approach on criteria prioritization which is one of the key issues of the methodology. This paper describes the application of Kraljic matrix on a large construction industry multinational group, identifying the necessary adaptations of the tool. Adjusting Kraljic tool for construction industry required specific key-factor selection, then AHP technique for factor prioritization. This work explores the output usefulness and its applicability on construction projects.

Keywords: supply chain management; Kraljic matrix; purchasing portfolio approach; purchasing strategies; construction industry.

1 Introduction

Portfolio approach on purchasing has been a relevant subject through last decades; it is well known that there is no one "perfect" purchasing strategy that could fit all kinds of purchased good or services. Thus segmentation is necessary in order to differentiate purchases and to adapt different strategies.

Construction industry is complex and conservative sector that resist changing when confronted with the risks associated with procurement of projects (Cheng, Li, Love, & Irani, 2001). Each construction project is unique involving a wide range of parties and activities what causes high market and process fragmentation. Being well known for its budget overruns, project delays (mostly due to supply disruptions), conflicts, claims and counter claims it is characterized by poor performance and low profit margins (Yeo & Ning, 2006).

The main criticalities in construction sector are the environment of complexity and uncertainty as the production is executed on a temporary site by a temporary organization of many different parties (owners, designers, constructors and labor force) that are dissolved after completion, what leads to opportunism focused on short term-relationships (Fearne & Fowler, 2006). From one side, the high customer influence on the project outcome and from the other the buyer-supplier relationships that are mostly of transactional nature where each partner is seeking for its own short-term benefit, avoiding serious investments in the relationship thanks to the opportunistic behavior. Despite the temporary configuration characteristic, the focus on price as the bid evaluation key parameter (for supplier selection) is one of the main sources for almost all the above exposed problems plaguing the industry (Hatush & Skitmore, 1998).

The lack of transparency and information sharing in this sector is outstanding what makes risk management a crucial but difficult task (Aloini, Dulmi, Mininno, & Pastore, 2010).

Risks such as supplier bankruptcy during the project, natural disasters or political changes that could cause a consequent supply disruption threaten this particular sector. Therefore, facing the high risk exposure due the criticalities and general focus on price for supplier selection it is evident the need for an improved approach on purchasing.

Among many portfolio approaches, Kraljic (1983) developed a bi-dimensional matrix based on the strategic impact and supply risk vectors. Given some purchasing portfolio, products can be grouped by similarity regarding the supply characteristics, (e.g. it can be purchased form the same supplier in the same order) and then rated accordingly different critical factors, e.g. total amount spent on that class during some period, the number of suppliers available, product scarcity (Kraljic, 1983).

Strategic importance/impact of purchasing can be measured by the cost of materials/total costs, value-added profile, and profitability profile and so on. Supply risk or in other words supply market complexity is expressed through factors such as the number of available suppliers for a given product, monopoly or oligopoly conditions, pace of technological advance, entry barriers, logistics costs and complexity.

However this method also received a lot of criticism: Selection of dimensions and respective weights is difficult (Gelderman & Van Weele, 2003); (Nellore & Soderquist, 2000); (Olsen & Ellram, 1997) the positioning of the items in the matrix is subjective and makes the model imprecise as well as the relative classification of items inside the matrix (Cox, 2001); (Ramsay, 1994).

This methodology has been largely used on manufacturing industries, although its application both on projects driven industries and construction industry is poor and rather unknown. Construction industry does suffer huge losses due supply delays and/or supply disruptions; therefore the selection of the right purchasing strategy is crucial (Aloini, Dulmi, Mininno, & Pastore, 2010).

The review revealed that there is an obvious lack of criteria prioritization in the literature. The best example, similar to AHP was the use of fuzzy comprehensive evaluation, a methodology very similar to AHP (Narasimhan, 1983). As follows, there are no other obvious examples of criteria weight assignment.

This paper describes the application of Kraljic matrix on a Portuguese large construction company, identifying the necessary adaptations of the tool. As the application of such methodology on construction industry is unknown, this research focused on the applicability and development procedure in order to analyze its usefulness with the real-world industry practitioners.

2 Theoretical background

2.1 Portfolio approach – Kraljic matrix

In the field of purchasing portfolio models, despite some other suggestions with minor nuances, Kraljic matrix has become the standard (Lamming & Harrison, 2001) (Gelderman, 2003). The portfolio approach on purchasing considering the strategic impact (internal) and supply risk (external) dimensions not only allow management to get a better perception on the bargain power and consequently choosing for the adequate strategy but do reduce the company risk exposure (Kraljic, 1983). Strategic importance can be measured by the cost of materials/total costs, value-added profile or profitability profile while supply risk through factors such as the number of available suppliers for a given product, monopoly or oligopoly conditions, pace of technological advance, entry barriers, logistics costs, complexity, etc. Each organization, in spite of meeting the best fit between the matrix as a tool and its reality, must select its particular criticalities. Given some purchasing portfolio, each product can be grouped by similarity regarding the supply characteristics, and then rated accordingly different critical factors.

Four categories arise from these two vectors. These are: Leverage, Strategic, Non-critical and, finally, Bottleneck. (Table 1)

Table 1 Kraljic matrix and typical items purchased

Strategic impact	High	**Leverage** Mix of commodities and specific materials	**Strategic** Scarce and/or high value materials
	Low	**Non-critical** Commodities, some specified materials	**Bottleneck** Mainly specified materials
		Low	High
		Supply risk	

Leverage items are known as the "best" placed items. They hold a considerable business share (high strategic impact) while the risk is reduced, nonexistent or already mitigated by some specific strategy. The supply process is mature and well established.

Strategic category is all about future strategy; this class of products has high impact on business and high risk. Specific management practices are required, e.g. long-term relationships with suppliers, continuity plans and strategic planning are crucial. Successful management of this category of products/services can mean the difference between the survival and demise of a company.

Bottleneck items are the most underestimated and ignored items. They have very low business impact, but a high supply risk. They are very likely to suffer supply interruptions and delays, among many other types of supply disturbances. The lack of such items can delay the whole projects or production lines, e.g. the lack of a cheap O-ring can be responsible for holding up an important piece of machinery.

Finally, the non-critical items have a low impact on business and low supply risk. This is the least important category, in which high performance and low cost are the drivers. For example supply process is mature, the supply market is healthy; there are plenty of choices and alternatives.

The breakup of the purchasing portfolio in the above-mentioned four categories backs management to choose better purchasing strategies and therefore building the best supply strategy according to the product and market characteristics.

Nevertheless this method received a fair degree of criticism (Gelderman & Van Weele, 2005): Selection of dimensions and respective weights is difficult and imprecise (Gelderman & Van Weele, 2003); (Nellore & Soderquist, 2000); (Olsen & Ellram, 1997) the positioning of the items in the matrix is subjective and makes the model imprecise as well as the relative classification of items in its independence inside the matrix (Cox, 2001); (Ramsay, 1994) (Ritter, 2000). This methodology fails to reflect the context of networks due to the oversimplified insight on buyer-suppliers relationship (Dubois & Pedersen, 2002) missing the concern for sustainable competitive advantage achieved through inter-firm relationships based on other aspects rather than the direct purchase itself (Wagner & Johnson, 2004).

2.2 Impact on the strategic recommendations

Each of the four categories requires different approaches in order to minimize supply risk and make the most of the buying power (Kraljic, 1983). Comparing the bargain power of the organization against the supply market three basic purchasing strategies come up: exploit, balance and diversify. Consequently managers should exploit the power in leverage category using its high bargain power. It can be achieved through target pricing, tendering and product substitution. Items which can cause problems and risks are located in the bottleneck category making adequate the volume insurance, security of inventories, vendor control and backup plans for such cases, through diversifying strategies. Strategic and non-critical items are the ones holding the bargain equilibrium between the buyer and supplier; non-critical items require efficient processing, product standardization, order volume and inventory optimization while strategic items require strategic partnerships.

The adequate purchasing strategies for strategic and bottleneck items are the ones that minimize risk what means moving the left in the matrix towards leverage and non-critical categories. The standard strategic recommendations are directions adequate to the most of the situations holding the item in some given position in the matrix or moving to another. (Table 2)

Table 2 Standard strategic recommendations (Adapted from Gelderman & Van Weele, 2003)

Items	Holding the position	Moving to another position
Leverage	"Maintain a partnership of convenience"	"Develop a strategic partnership" (moving to Strategic)
Bottleneck	"Keep safety stocks"	"Decomplex the product, find a new supplier" (moving to non-critical)
Non-critical	"Individual ordering"	"Pooling of requirements" (moving to leverage)
Strategic	"Maintain a strategic partnership" "Accept a locked-in partnership"	"Terminate a partnership, find a new supplier" (moving to leverage)

While there are standard strategic, construction industry projects are often developed in remote conditions with geographically distant suppliers where the logistical infrastructure is highly undeveloped. There are two adequate strategic directions adequate for such cases; one is the use of remote purchasing agents for the strategic items while the other is the use of logistic management systems (Gelderman & Donald, 2008). Both these strategic directions do tend to reduce the supply risk by dealing with the distance and the uncertainty.

2.3 Application of Kraljic approach

Kraljic approach has been applied on several different industries (Gelderman & Donald, 2008). A brief chronological analysis on the keyword "Kraljic" in research databases seeking for practical applications revealed very few suitable results. De Haan et al. (2003) used Kraljic portfolio approach on a natural rubber industry without doing any explicit criteria prioritization using only "availability and technical quality" for risk measurement and "price" for profit impact. Zhao et al. (2007) focused on factor analysis, matrix indicators (criteria) definition and quantification. Later Gelderman and Mac Donald (2008) studied the adaptation of this methodology to an undeveloped logistic infrastructure applying it to an oil company case using several criteria without mentioning any prioritization. Caniels and Gelderman (2007) focused on power and interdependence in buyer supplier relationships using the purchasing portfolio approach based on a questionnaire aimed at purchasing professionals of various sectors. Liu and Xu (2008) executed its application on steel industry, selecting the suitable criteria using fuzzy comprehensive evaluation, performing criteria prioritization by means of a methodology very similar to AHP presented by Narasimhan (1983). Later, based on the observation of a sample of 10 organizations from different sectors, Pagell et al. (2010) developed a sustainable purchasing portfolio matrix based on Kraljic matrix yet without any practical application of the new model. Lee and Drake (2010) used the portfolio approach on two elevator manufacturers for component purchasing strategies development, seeking to improve the original Kraljic model, using the AHP for component prioritization but not criteria. Applied to a refrigerator making company, Seifbarghy (2010) relied on fuzzy numbers in order to quantify and prioritize most of the qualitative criteria. Still concerning analytical scoring of different commodities using a more objective approach, Padhi et al. (2011) used fuzzy multi-attribute scoring to assign weights and multidimensional scaling for positioning in the matrix, applying it to a Rural Development Department commodities purchasing portfolio.

These are the main Kraljic matrix practical uses found in the literature; therefore it is clear that its application on construction industry is unknown or even absent and as well as factor prioritization is a rare and yet immature practice.

3 Case Study

The case study focuses on the application of Kraljic portfolio matrix on a Portuguese large construction company that operates worldwide, identifying the necessary adaptations of the tool considering the sector characteristics and discussing its applicability.

Operating primarily in Portugal (where it is based), Angola, Mozambique and Guinea-Bissau, among many other countries, this company provides construction and rehabilitation services for almost any kind of infrastructure as well as contract management services is a publicly held company with a market capital of more than €620M. This particular case was found suitable to such study because of the wide and well-established international supplier base (more than 1K suppliers) and experience result of more than ninety years of activity constructing worldwide.

3.1 Methodology

A period of 6 months was scheduled to conduct the research with the team consisting of the Supply General Manager, Internal Control General Manager, Division Manager and International Procurement Manager. The main objective was to investigate the applicability of the Kraljic purchasing portfolio matrix for construction industry and to evaluate the adapted portfolio matrix with the practitioners. The study was unspecific to any particular project thus encompassing all the purchases during the year of 2010.

The research included 6 key steps: (1) Literature review; (2) Criteria selection and prioritization; (3) Product portfolio analysis; (4) Matrix construction; (5) Design and filling in the matrix; and (6) interpretation of results. Following an in-depth literature review on the topic (step 1), several open interviews were performed by two researchers with key practitioners in order to accomplish the steps 2 to 6. After criteria selection, the Analytical Hierarchical Process model was used for criteria prioritization involving the whole team.

Product portfolio analysis (step 3) consisted in grouping different items into categories, both goods and services. Starting with a database containing more than 4000 items, the selection principle used encompassed the total amount purchased during one year of activity and grouped regarding the possibility of being purchased in the same order from the same supplier.

The grouping consisted of various phases; the initial database hierarchical arrangement was suitable for the research purpose what eased the process. This triage resulted in 29 classes representing 75% of the total amount purchased as some of the classes were excluded due some particularities, e.g. the excessive amount spent subcontracting of electrical installations made during the year due to a special project.

Then, after criteria selection and prioritization each selected category was positioned on the matrix by means of a questioner filled in as a team exercise. Each criterions answer was codified to values between 0 and 1 multiplied by the respective criterion weight. The sum of all the weighted criteria and respective answers represented the final score of each dimension of the matrix.

Then, after criteria selection and prioritization each selected category was positioned on the matrix by means of a questioner filled in as a team exercise, each criterion had several possibilities of answer. Each criterions answer was codified to values between 0 and 1 multiplied by the respective criterion weight. The sum of all the weighted criteria and respective answers represented the final score of each class inside the dimensions of the matrix.

$$Score_j = \sum_{i=1}^{n} CriteriaWeight_i * Answer_i$$

Where:

$Score \in [0,1]; Answer \in [0,1]; j \text{ is the class}; i \text{ is the criteria question}.$

3.2 AHP application on criteria prioritization

Analytical Hierarchical Process (AHP) in one of the multivariate analysis techniques that help to reduce the randomness of subjective evaluations. Complex decision making requires the establishment of different "trade-offs" between different criteria (Goodwin & Wright, 2004). In order to define which are the priorities in the decision process the decision elements are compared with each other and weights assigned (Zahedi, 1986). The AHP application is quick and simple what makes it suitable for real world practitioners of many different backgrounds. Although, a very similar method was applied on criteria prioritization (Liu & Xu, 2008), AHP have never been explicitly used for such propose.

3.2.1 Criteria selection

Decisions based on purchasing portfolio models are proven to be sensitive to the choice of criteria and weights (Day, 1986). Concerning strategic impact, the generic selection criteria suggested by Kraljic in terms of the volume purchased, percentage of total purchase cost, or impact on product quality or business growth is not totally suitable for construction sector. As well as the availability, the number of suppliers, competitive demand, make-or-buy opportunities, storage risks and substitution possibilities regarding the supply risk need some adaptations. Concerning the problem of selecting the most appropriate variables to use (Nellore & Soderquist, 2000), open interviews with the team of expert cross-functional practitioners and researchers discussing the outcome of the literature review on selection criteria revealed a new list of criteria assumed as valid for the construction sector. Each criterion answers were positioned on a scale between 0 and 1 in a team exercise with practitioners considering the different importance of each answer to some specific criterion.

3.2.1.1 Strategic impact

Construction sector is a project driven production, practitioners considered that one of the most important to classify the strategic impact on some given item is by its importance on the project development sequence, e.g. concrete or construction steel which are key-elements in almost all early stages of project sequences. The perceived bargain power of the buyer may seem more an outcome than a criterion but this was a way of considering the buyer-supplier interdependence in the conservative construction sector; relying on other commercial bounds, interpersonal relationships and past experience what quite often play an decisive role on the supplier selection, its performance and integrity addressing one of the critiques made to this approach on the concern for sustainable competitive advantage through inter-firm relationships (Wagner & Johnson, 2004). (Table 3)

Table 3 Construction sector strategic impact selected criteria

Criteria
C1) Total amount purchased
C2) Expected growth in demand
C3) The level of standardization of the product
C4) Perceived bargain power of the buyer
C5) The importance of the product in the project sequence

As the total amount purchased was an already known value, it was expressed through a value between 0 and 1.

3.2.1.2 Supply risk

Supply risk criteria are extensive and there are many factors that influence the external risk exposure, the problematic here is to choose the most important ones in order to make the list short. A wide range of criteria makes the methodology unpractical when applied to broad purchasing portfolios.

About construction sector particularities, the criterion of supplier availability on the constructions site local market was considered important as the purchasing team normally spent lot of resources working on it. Practitioners were aware of many different risk factors that threaten their business but have never discussed its hierarchy of relative importance and likelihood. (Table 4)

Table 4 Construction sector supply risk selected criteria

Criteria
C1) Suppliers available on the constructions site local market
C2) Product availability
C3) Substitution possibilities
C4) Product storage costs
C5) Legal requirements
C6) Ease of supplier substitution in case of failure
C7) Logistical proximity of supplier market
C8) Number of available suppliers

The number of available suppliers was considered to be the amount of suppliers used during the year; practitioners agreed that they could be considered "active" suppliers, what is rather different from C1 that refer to any other potential suppliers that the company is aware of yet never done business with. It is important to distinguish "active suppliers" from the "potential suppliers", because the number of potentially available ones was much greater and vague yet the already proven ones are much easier to reach and do business agreements with.

The number of available suppliers was also a sensible matter as it value couldn't be used linearly. Regarding this particular case, number of suppliers ranging from 2 to 70 it is not suitable to consider is as a percentage so the agreed normalization between 0 and 1 was the (number of available suppliers)$^{-0.8}$.

3.2.2 Criteria prioritization – AHP application

The AHP application was performed as a team exercise, each criterion was compared to the rest of the criteria following the AHP methodology. Both strategic impact and supply risk criteria scored good consistency ratios (lower than 10%). Total amount purchased and the number of available suppliers resulted as the heaviest criteria in the strategic and supply risk dimensions respectively. (Table 5 and Table 6)

Table 5 Strategic impact criteria AHP application and weights

Criteria	C1	C2	C3	C4	C5	Weights
C1) Total amount purchased	1	9	8	6	5	**61,9%**
C2) Expected growth in demand	1/9	1	1	1/3	1/4	**6,0%**
C3) The level of standardization of the product	1/8	1	1	1	1/3	**7,5%**
C4) Perceived bargain power of the buyer	1/6	3	1	1	1	**10,9%**
C5) The importance of the product in the project sequence	1/5	4	3	1	1	**13,6%**
Eigenvalue (λ= 5,175); Consistency Ratio (CR=3,9%)						

Table 6 Supply risk criteria AHP application and weights

Criteria	C1	C2	C3	C4	C5	C6	C7	C8	Weights
C1) Suppliers available in the constructions site local market	1	1/2	1/2	2	1	1/3	1	1/7	**5,9%**
C2) Product availability	2	1	1	4	3	1	2	1/5	**10,6%**
C3) Substitution possibilities	2	1	1	3	2	1/2	1	1/6	**8,3%**
C4) Product storage costs	1/2	1/4	1/3	1	1	1/5	1/2	1/9	**4,0%**
C5) Legal requirements	1	1/3	1/2	1	1	1/4	1/2	1/8	**4,8%**
C6) Ease of supplier substitution in case of failure	3	1	2	5	4	1	2	1/4	**13,1%**
C7) Logistical proximity of supplier market	1	1/2	1	2	2	1/2	1	1/7	**6,7%**
C8) Number of available suppliers	7	5	6	9	8	4	7	1	**46,7%**
Eigenvalue (λ= 8,221); Consistency Ratio (CR=2,2%)									

3.3 Results

After completing the questioner and inserting the data in the model all 29 classes took place in the matrix. It was considered that the matrix was equally divided on 50% for each dimension axis, e.g. strategic items are the ones that score more than 50% both strategic impact and supply risk dimension.

Table 7 Distribution of the purchased amount among the four categories

Categories	Strategic	Leverage	Bottleneck	Non-Critical
Percentage of total amount purchased	27%	37%	22%	14%
Number of classes (out of 29)	4 (14%)	7 (24%)	11 (38%)	7 (24%)

The quality of the distribution was judged by means of a several assumptions: First, the equilibrium of shares of the amount spent during the year of activity. Second, the average tendency of the distribution should be central. Third, it is expected that both leverage and strategic categories represent the biggest share of the portfolio. (Table 7 and Table 8)

Concerning the risk exposure, 49% of the total purchased value falls into high risk strategic and bottleneck categories what can justify the future application of risk mitigation strategies. (Table 7)

Table 8 Assumptions of distribution quality judgment

Assumptions	Expected	Obtained
A1) Equilibrium of shares of the amount spent during the year of activity	None inferior to 10% None superior to 50%	27%;37%;22%;14%.
A2) Average tendency of the strategic impact score and supply risk score	Both (50% ± 5%)	46% & 52%
A3) Leverage and strategic category must represent the biggest share of the portfolio	Superior to 50%	64%

Analyzing Figure 1 concrete is strategic as it holds the highest strategic impact and medium-high supply risk. It is essential for the construction and there is a scarcity of suppliers due the strict quality requirements and legal implications. One possible risk mitigation strategy is the approval of more than one concrete specification in the beginning of the project allowing some flexibility. It is wise to establish strategic partnerships with concrete suppliers in order to guarantee is supply reducing the supply risk.

Scaffold platform and score class is difficult to obtain as there are few suppliers in the market and they are located in the Chinese market making this product the one with highest risk taking place in the bottleneck category. Geotechnical engineering is a highly specialized activity being one of the first phases of the construction project, the further project development depends on it success what makes it an important item, its scarcity of supply makes it bottleneck class. Consequently the purchasing team should be looking for alternative suppliers in order to reduce the supply risk of these classes.

Stone due its natural qualities is often a rare product that can only be obtained from some specific supplier in the world, although it is mostly used for decoration thus the amount spent is quite low what makes it a clear bottleneck item. Wooden furniture suffers from the same problem as stone due its natural characteristics. Both wooden furniture and stone have high supply risk because these items are chosen by architects and designers in early stages of the project, making this item specification unique and obtainable from maybe one or two suppliers in the market. Substitution of these items is time consuming and consequently expensive. The suggested mitigation strategy is to insist that architects and designers loose the material specification in the project phase allowing alternatives in case of supply disappearance.

There are some non-critical classes like the rental of general transport equipment what contain all postal and transport services. Facing a wide range of supply, highly standardized service allow low prices and low supply risks. High standardization makes the sourcing of some classes non-critical, such is are the paints or the rental of specific excavation machinery that are available worldwide.

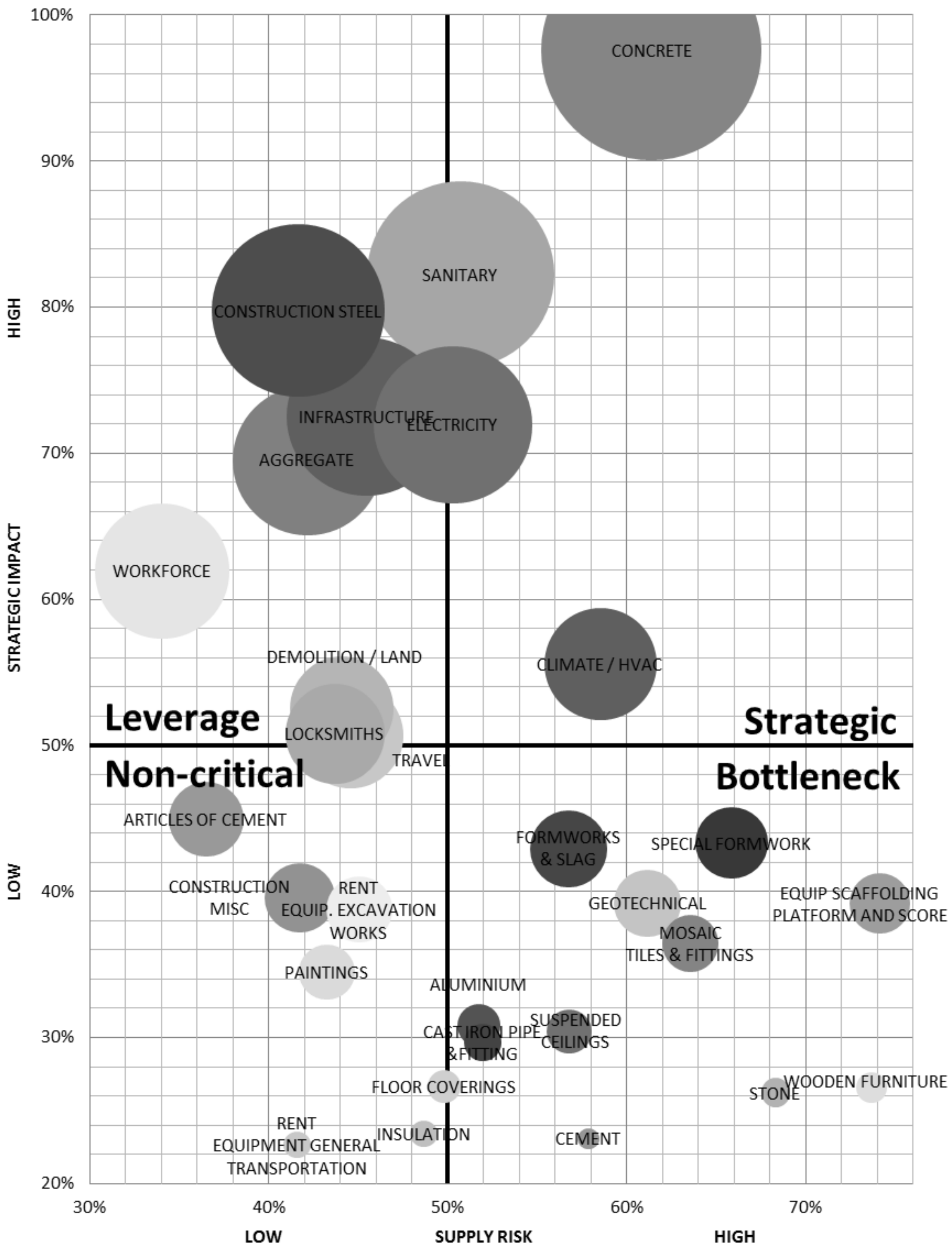

Figure 1 - Portfolio matrix plot (bubble proportional to the amount spent)

Workforce represents all non-specialists, it is a clear leverage as the market is full of offer and they are essential to construction representing a great amount spent due to the high volume of people hired. Items like construction steel and construction aggregate are clear leverage products mostly because of the high standardization and specialized supplier availability. These products should be price driven and sourced through open biddings to incentive competition among suppliers.

4 Conclusions and recommendations

The contribution of this case-study addresses the presented research gap regarding the application and adaptation of Kraljic matrix on construction industries, as well as the successful criteria prioritization using the AHP technique. Facing numerous reasons for poor project performances, sector criticalities and risks, the excessive focus on price as the key driver for supplier selection, reveals the lack of efficient management solutions regarding purchasing in this particular sector. This research makes a step further adapting and applying already existing methods on new sectors.

Most of the categories achieved the expected position in the matrix. The post-validation of the matrix output has been done individually first and finally in group. Practitioners agreed that such methodology is an efficient management tool in order to develop purchasing strategies and can easily be performed on a regular basis. They also recognized the importance of such exercise being independent of any particular project and its consequent "full compatibility" with the business. However, it is unclear the decision on whether an item changes its category inside the matrix. The team agreed that management should avoid blind judgment on the categorization of some given class; instead it is important to consider the relative position of classes regarding each other. Obvious positions that are located on the extremes of the matrix leave no doubts but ones near the borderline between categories should be judged carefully.

The strategic impact revealed that any criteria but the amount spent had little use as practitioners have the natural tendency to consider everything "very important" when isolated, the assignment of weights is an efficient way of dealing with this tendency.

The top management agreed on the importance of having such tool as an effective "photograph" of the purchasing portfolio revealing the supply risk exposure and a way of measuring the relative impact of supply risk mitigation strategies when repeated over time.

This research has also shown that AHP is an effective way of dealing with one of the key problems of Kraljic matrix yet keeping it simple and usable by the practitioners.

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