The lean and agile purchasing portfolio model

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Abstract

Purpose – The aim of this paper is to present a purchasing portfolio model for determining purchasing strategy at the component level of a product to support business strategy, addressing weaknesses in the often cited Kraljic-type models. The work draws on Fisher's model to match supply strategy to product nature. However, Fisher's model was criticised very recently by Lo and Power in this journal because it is unclear how the "leagile" option should fit into it. This paper addresses this issue.

Design/methodology/approach – The new portfolio model is based on the literature, particularly Fisher's seminal work. It is then applied to two case studies; an electric boiler manufacturer and an elevator manufacturer, both in South Korea. The analytic hierarchy process (AHP) is used to position purchased components in the model.

Findings – Different purchasing strategies should be assigned to different components according to their impact on the competitive priorities. As the electric boiler is a functional product, while the elevator is an innovative product, the case studies show how this can vary across the two product-types identified by Fisher.

Research limitations/implications – The new model has been tested on only two case studies, which limits the ability to generalise the findings. Future work will use the lean and agile purchasing portfolio model in research and knowledge exchange activities with other industrial partners to further develop and test its efficacy.

Originality/value – The new model captures the finding of Fisher and others that products should be classified as functional or innovation to determine their suitability for lean or agile supply respectively. However, this classification is extended here to the component level and with the addition of the leagile and non-strategic supply options, and it depends on the impact a component has on the four competitive priorities; cost, quality, time and flexibility.

Keywords Purchasing strategy, Purchasing portfolio model, Lean, Agile, Leagile, AHP, Republic of Korea, Analytical hierarchy process, Purchasing

Paper type Research paper

1. Introduction

A manufacturer's purchasing strategy for components of its products, i.e. strategic purchases, should be aligned with its business strategy to achieve competitive advantage (Cousins, 2005). For example, if the business strategy is to compete on price, then the purchasing strategy must focus on cost. If business strategy is focused on high variety products, then purchasing must focus on flexibility. A manufacturer must determine and manage its purchasing strategy on the basis of its business strategy and a deep understanding of its products (Watts *et al.*, 1995) and their components (Drake and Lee, 2009) to achieve "strategic purchasing". The amount that manufacturers spend on purchased materials and components is typically 50 to 70 per cent of the value of sales (van Weele, 2005), so their success is heavily influenced by the performance of their purchasing at the component level. Purchasing is clearly a critical activity for a manufacturing business (Parikh and Joshi, 2005) (Sarkis and Talluri, 2002) to enable high quality, high variety, low cost and fast delivery of the end-product.

Purchasing portfolio models have received a great deal of attention in the academic and business fields for assigning suitable purchasing strategies. They are easy to understand and give practical guidelines on how to manage different purchased items (Dubois and Pedersen, 2002). Surveys found that 74 per cent of Dutch purchasers (Gelderman, 2003) and 55 per cent of French purchasers (Kibbeling, 2005) in the manufacturing and engineering sectors use purchasing portfolio analysis. A survey of 122 British companies in the manufacturing, service and other industry sectors found that purchasing portfolio analysis was the second most used of 65

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Supply Chain Management: An International Journal
18/1 (2013) 3–20

[DOI 10.1108/13598541311293140]

Received 6 December 2011
Revised 27 March 2012
Accepted 17 April 2012

purchasing and supply tools, with vendor rating coming first (Cox and Watson, 2004).

In the literature review section that follows, weaknesses are identified in existing purchasing portfolio models, which lead to the new purchasing portfolio model presented in this paper to address these weaknesses. Section 3 considers the possible supply options. Section 4 introduces the lean and agile purchasing portfolio model to allocate components to suitable supply options and thereby purchasing strategies. Section 5 considers how to measure the impact of a component on the competitive priorities of cost, quality, time and flexibility. This is needed to place a component in the purchasing portfolio model. An overview of how a purchased item is placed in the model is given in Section 6. The nature of the purchasing strategies proposed by the portfolio model are discussed in Section 7. The two case studies used to demonstrate the application of the portfolio model are introduced in Section 8. The implementation of the model for the case studies is described in detail in Section 9. This implementation uses the Analytic Hierarchy Process (AHP) to quantify the extent to which a component impacts the leanness and agility of the supply chain. Section 10 presents the analysis of the results of applying the model in the case studies and Section 11 presents the conclusion.

2. Literature review

Kraljic (1983) classified purchased items by positioning them in the four quadrants of the portfolio model formed by the two dimensions, "importance of the purchase" and "complexity of the supply market", with the quadrants representing different purchasing strategies. Following on from Kraljic, others have developed portfolio models based on similar two-dimensional frameworks, e.g. (Bensaou, 1999) (Olsen and Ellram, 1997) (Lee and Drake, 2010). Such portfolio models have become popular, being adopted in many industries (Lee and Drake, 2010).

However, there is a downside to the Kraljic-type dimensions following Fisher's (1997) seminal work "What is the right supply chain for your product?". Fisher classified products into two types, functional products characterized by stable demand, long life cycles, low profit margins and low variety, and innovative products with volatile demand, short life cycles, high profit margins and high variety. For example, white goods (domestic appliances) such as washing machines are functional products. They are made to stock according to forecasts to satisfy a large and steady demand. An example of what is meant here by an innovative product is high-end office seating. This can come in a very wide range of colours and fabrics and with numerous other options specified by the customer such as different armrests and headrests and some dimensions of the seat (MacCarthy and Brabazon, 2003). Such seats are made to individual customer order. Differences between functional and innovative products are summarised in Table I.

Functional products are suited to lean supply with forecast-driven planning as their demand is relatively predictable, while innovative products are suited to agile supply with demand-driven planning to deal with their unpredictable demand (Childerhouse and Towill, 2000) (Mason-Jones *et al.*, 2000) (Lysons and Farrington, 2007). Fisher's findings are widely accepted within the literature, e.g. (Li and O'Brien, 2001) (Lee, 2002) (Kaipia and Holmstrom, 2007). Clearly, whether a product is functional or innovative, and thereby suited to lean or agile supply respectively, should be taken into consideration in developing purchasing strategy. Kraljic's dimensions, "importance of the purchase" and "complexity of the supply market" fail to do this, as they do not consider whether a product is functional or innovative. However, the portfolio model presented here does, by basing its dimensions on measures of the extent to which a product requires leanness and agility in its supply, i.e. it is based on Fisher's findings.

Table I Characteristics of functional and innovative products

	Functional products	Innovative products
Life cycle	Long	Short
Variety	Low	High
Volume	High	Low
Demand	Stable/predictable	Volatile/unpredictable
Production driver	Forecast	Demand/customer-order
Manufacturing strategy	MTS	MTO
Production control	JIT/Kanban	MRP
Average stockout rate	Lower	Higher
Components	Standard	Standard and specific

This argument is taken a step further here by viewing a product as being made of standard and specific components, specified by the supplier and the buyer respectively (Lysons and Farrington, 2007). Barker (2001) found that in a typical customised product, approximately 80% of components are standard while 20 per cent are specifically designed. As one moves from engineer-to-order through make-to-order and assemble-to-order to make-to-stock, i.e. from bespoke to standard end-products, the emphasis in the component mix moves from specific to standard. In accordance with Table I, standard components correspond to functional products, so that they are suited to lean supply, while specific components correspond to innovative products so they are suited to agile supply. Since, as discussed later, different purchasing strategies support lean and agile supply respectively, it follows that the formulation of purchasing strategy for a component should consider whether the component is standard or specific and thereby suited to lean or agile supply respectively.

Fisher's model has come in for criticism in this journal very recently from Lo and Power (2010). They point out that "the literature remains unclear as to how the "leagile" system should fit into Fisher's (1997) model". This paper addresses this issue.

3. The supply options

Lean supply aims to provide good quality products at low price by focusing on waste removal while agile supply aims to provide a quick and flexible response to more variable customer needs by focusing on lead-time and service level (Naylor *et al.*, 1999) (Robertson and Jones, 1999) (Agarwal *et al.*, 2006) (Zhang and Sharifi, 2007). Agility and leanness are business wide capabilities that permeate throughout the philosophy and mindset of an organisation and not just its processes and systems.

Although "going lean" realises significant improvements in both cost and quality (Piercy and Rich, 2009), paradoxically, quality is both a prerequisite and an outcome (Ahlstrom, 1998). As Hines and Rich (1997) stated, "[...] the systematic attack on waste is also a systematic assault on the factors underlying poor quality [...]". Looking at the specific example of poultry products, van der Vorst *et al.* (2001) found lean supply being used to achieve market winning quality, as well as cost. This takes us to what Lamming *et al.* (2000) argued, that the supply chain for functional products must focus primarily on cost and quality, whereas for unique innovative products, the emphasis should be on speed and flexibility.

In practice, lean and agile supply can be combined in one of three ways (Towill and Christopher, 2002) to give a third option termed "leagile" supply. The first way is to use a strategic stockholding decoupling point in the supply chain (Rahimnia and Moghadasian, 2010). Lean supply is adopted for cost-effectiveness upstream of the decoupling point, while agile supply is adopted downstream to achieve high levels of customer-service in a volatile marketplace; downstream production is demand-driven to meet highly variable demand, while upstream it is forecast-driven with JIT/Kanban execution to meet demand levelled through aggregation (Mason-Jones *et al.*, 2000; Naylor *et al.*, 1999). The decoupling point separates responsive pull production based on customers' orders from the supply and stocking of components based on planning and level control (Hoekstra and Romme, 1992). The second way to combine lean and agile is applicable when demand can be decoupled into a substantial level base-load and surges on top. Lean supply is then used to satisfy the base-load while agile supply is used for the surge. The third way is applicable when demand is seasonal. Lean supply is used in the quiet season to build a low-cost, high-quality anticipation stock for the busy season; while agile supply is used in the busy season to meet surges in demand for particular product variants, perhaps using postponed manufacture.

There is a fourth supply option that appears ubiquitously in the portfolio approaches to purchasing and in inventory management methods such as the ABC approach. This concerns the concept of non-strategic items, i.e. components that have little impact on achieving competitive advantage in the end-product. In ABC analysis, these are the items on which there is low total value of spend, i.e. the C-items. However, this highlights a weakness of the ABC approach as cost of consumption is not the same as total cost and a low cost component can still be critical to other competitive priorities such as quality; so a more strategic approach to determining these items is required as presented here. Purchasing strategies for non-strategic items are discussed later, but the key point is that these items have little effect on competitive advantage.

4. The lean and agile purchasing portfolio model

The purchasing portfolio model presented here allocates components to one of the finite set of four supply options consisting of lean, agile, leagile and non-strategic, so that purchasing strategies can be proposed accordingly. Note, single definitive purchasing strategies are not proposed for each supply option, but rather the general characteristics of the strategies to be developed for specific applications. The use of the model raises the question, "How do we perform the allocation?". It was argued previously that this should depend on whether a component is standard or specific. But how does leagile fit with the assertion that there are standard and specific components requiring lean or agile supply respectively? The answer lies in lean being best for quality and cost, whereas agile supply is best for time and flexibility, so if a component has a high impact on all four factors "leagility" is needed. There is also a need to identify the non-strategic components, i.e. those that do not have a significant impact on quality, cost, time or flexibility. The need to consider the strategic importance of a purchase is a central tenet in the previously cited literature on purchasing portfolio models.

The allocation to supply options is performed in the two dimensional framework formed by the level of a component's combined impact on cost and quality, which indicates the level of need for leanness, and the combined impact on time and flexibility, which indicates the level of need for agility, as shown in Figure 1. How these impacts are measured is introduced in the next section.

The significance of an impact depends on the importance of the competitive priority being impacted. For example, if a component has a big impact on cost and the business is competing on cost, then the impact is very important. If the business competes on flexibility, then the impact on cost is less important. This means the strength of an impact must be tempered by the importance of the competitive priority. The assessment of the strength of the impacts on the competitive priorities, the importance of the competitive priorities and the tempering of the former by the latter is achieved here by the application of the Analytic Hierarchy Process (AHP).

5. Measuring the impact of a component on a competitive priority

In order to support business strategy, the importance of a particular purchase must be determined by the business's competitive priorities (Lee and Drake, 2010) and it is widely accepted that the four core competitive priorities are cost, quality, time and flexibility, e.g. (Hayes and Wheelwright, 1984) (Dangayach and Deshmukh, 2001) (Krajewski *et al.*, 2009). The impact of a component on the four competitive priorities is measured here on the basis of the impact on the factors in Table II and this is justified as follows.

5.1 Quality

The importance of quality is measured on the basis of the importance of durability, reliability and innovation. Quality is associated with conformance to specifications and meeting the customers' expectations (Dangayach and Deshmukh, 2001) (Miltenburg, 2005) (Slack and Lewis, 2011) and durability and reliability in particular must conform (Chan and Chan, 2004). These two measures are often used as measures of quality (Krause *et al.*, 2001) (MacKenzie and Hardy, 1996) (Park and Hartley, 2002) (Shin *et al.*, 2000). Innovation is included as a measure of quality as it can be central to achieving competitive advantage, and high innovation in purchased components is often the quickest and easiest way to improve the quality of the end-product (Burt, 1989).

5.2 Flexibility

The importance of flexibility is measured by the importance of volume flexibility, modification flexibility and technological

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Figure 1 Lean and agile purchasing portfolio model

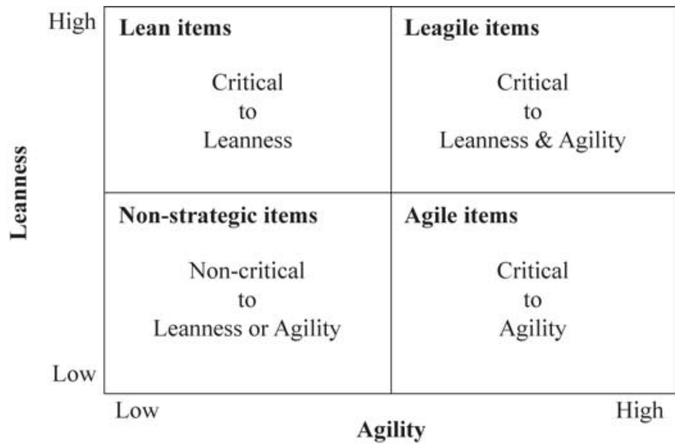


Table II Two dimensions of the lean and agile component model

Factors influencing leanness	Factors influencing agility
Quality factors	*Flexibility factors*
1. Component durability	1. Volume flexibility
2. Component reliability	2. Modification flexibility
3. Component innovation	3. Technological capability
Cost factors	*Time factors*
1. Purchasing cost	1. Delivery speed
2. Inventory cost'	2. Delivery reliability
3. Quality cost	3. Development speed

capability. Volume flexibility prevents stock out when demand surges and modification flexibility enables high variety and personalised products. Technological change is one of the principal factors of competition (Porter, 1985) and new technologies present opportunities for new products (Christensen and Bower, 1996).

5.3 Cost

The importance of cost is measured by the importance of purchasing cost, inventory cost and quality cost. Purchasing cost is a fundamental component of overall cost (Kraljic, 1983) (Olsen and Ellram, 1997), while inventory cost is important in the wider context of supply chain management (Childerhouse and Towill, 2000). The quality of components has substantial implications for cost (Bowersox *et al.*, 2002). Purchasing high quality components reduces the inventory cost (Nicholas, 1998) and production costs by eliminating rework, scrap and inspection (Pitts and Lei, 2000).

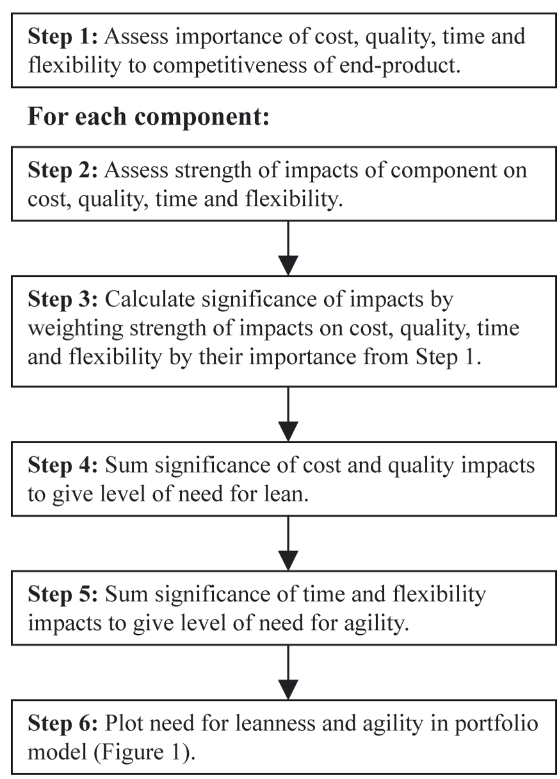
5.4 Time

The importance of time is measured on the basis of the importance of delivery speed, delivery reliability and development speed, as they can be critical to the success of a product (Christopher and Towill, 2000). For example, a competitive advantage can be gained by purchasing from suppliers who offer reduced delivery times (Lee and Billington, 1992).

6. Positioning a component in the portfolio model

An overview of the method used to position a component in the portfolio model is given in Figure 2. At the core of the method is the use of the AHP to implement Steps 1 to 3. The AHP was explained in a detailed and detached way very recently in this journal (Ho *et al.*, 2011). To complement this, it is explained here through case studies.

Figure 2 Overview flowchart of process for placing components in lean and agile purchasing portfolio model



Note: Steps 1-3 performed using the Analytic Hierarchy Process (AHP)

7. The portfolio-model purchasing strategies

This section discusses the nature of the purchasing strategies corresponding to the supply options to which components are allocated by the purchasing portfolio model.

7.1 Lean

Components that impact quality and cost are suited to lean supply. Supplier relationships should be based on long-term agreement on quality and cost, and efficiency programmes developed with suppliers to improve cost and quality, such as Toyota's Construction of Cost Competitiveness for the 21st Century (CCC21) programme (Liker and Choi, 2004). Firms should ensure these are standard components used in various final products. This will reduce overall component stock levels and production costs because of the increase in batch production sizes and other economies of scale (Benton and Krajewski, 1990; Berry *et al.*, 1992; Persona *et al.*, 2007). Moreover, standard components can be bought in large quantities by global sourcing (Jin, 2004) (Smith, 2002) providing immediate and dramatic improvements in cost and quality (Lysons and Farrington, 2007; Monczka *et al.*, 2011). If the demand for these items is made stable and predictable, i.e. levelled through aggregation, a push production system is more appropriate than a pull system. However, the firm can use JIT when the final production schedule is calculated and executed at the low level, although the forecast is calculated at the planning level by using a push system (push planning, pull execution) (Naylor *et al.*, 1999). So, JIT rather than MRP should be more suitable in the procurement of these items. The re-order point stock control method can be an effective method for managing globally sourced components in particular (Chandra and Grabis, 2004).

7.2 Agile

Components that impact flexibility and time are suited to agile supply. Long-term close relationships should be created with suppliers and, to improve flexibility and lead-times, there should be frequent exchange of information. Local suppliers may offer higher flexibility for components that are changed or modified often and close relationships with them will enhance the ability to make wide changes in the final product (Patti, 2006). For example, Zara and Benetton achieved high levels of flexibility by working closely with local suppliers (Christopher *et al.*, 2004). Monczka *et al.* (2011) also found that firms using local suppliers have reduced and more reliable delivery times as required to be responsive. Small suppliers are good sources for agile supply because they usually more attentive and responsive (Lysons and Farrington, 2007).

7.3 Leagile

Leagile supply is for items that have a high impact on not only flexibility and time, but also quality and cost, so they are suited to lean and agile supply. The cost and quality of these items might not contribute directly to winning business, but there might be a need to reduce cost and improve quality to stay in the market. In adopting leagile supply there is a need to consider which of the three ways of combining lean and agile are most suitable.

Where lean and agile is applied to the base-load and surge respectively, or split seasonally, components will have different purchasing strategies accordingly. For example, low-cost but longer lead-time global suppliers could be used for lean supply, while more expensive but quicker and flexible local suppliers could be used for agile supply (Bruce *et al.*, 2004). This could also include different service level agreements to meet the different performance objectives. Some businesses keep one type of supply in-house while outsourcing the other, i.e. distinct make-or-buy decisions can be made for the lean supply and the agile supply. Lean supply might be seen as a core skill while the responsive capability might be outsourced from a specialist that maintains responsive capacity economically by having several customers. The opposite is also possible as responsiveness might be seen as mission critical and difficult to obtain from suppliers, so it must be a core, in-house capability.

7.4 Non-strategic

Non-strategic items have low impact on the competitive advantage of the end-product, so it will not pay to reconsider frequently their suppliers (de Boer *et al.*, 2001). Non-strategic items require only simple loose control, as recommended for C-items in the ABC approach, even though many items may fall into this category. A key issue with these items is that their purchasing and supply costs can be very high relative to their value, so the focus should be on efficient purchasing and supply, reducing complexity and cost (van Weele, 2009). Transaction costs should be minimised through standardising these items, automating transactions and using simple source selection processes to govern relatively short contracts (Moore *et al.*, 2002). A market-based, arms-length relationship with the suppliers is appropriate as there is little to be gained by investing in the relationship. Simple inventory management systems should be used, such as two-bin stock control.

8. Case studies and data acquisition

To apply the lean and agile purchasing portfolio model, an electric water boiler manufacturer and an elevator manufacturer were selected, both in South Korea. The electric boiler is an example of a functional product according to Fisher's classification whereas the elevator satisfies the innovative class, allowing comparison of the component purchasing strategies produced for products in the two different classes.

In South Korea, the domestic electric water boiler is associated with off-peak night-time electricity. It generally heats the water during the night, when cheaper off-peak tariffs are available, and releases the heated water during the day. The electric boiler firm offers a small range of boilers satisfying the Korea Electric Power Corporation (KEPCO) standards. A characteristic of electric boilers is industry standard sizes that are suitable for any application. So competition in the electric boiler market is very much on price rather than strategic positioning.

By contrast, an elevator is designed for a specific building, taking into account such factors as the height of the building, the number of users on each floor, and the expected usage periods. The number of components varies with the number of stories and the complexity of the design of the elevator. A job begins with a list of the customer's requirements such as speed and capacity, desired style options and a set of blueprints describing the dimensions of the building. An appropriate set of elevator components is specified and ordered from the component suppliers for subsequent assembly and installation in the recipient building. This is a

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high-variety, low-volume market in which competition is very high. The differences in the situations of the electric boiler and elevator manufacturers are summarised in Table III.

The data for this model mapping exercise was gathered by questioning, in each company, staff who were frequently involved directly or indirectly with component purchasing. They came from the purchasing, engineering, operations management and accounting functions. These samples give coverage of different key functions and therefore perspectives. Nicholas (1998) referred to purchasing, manufacturing operations, engineering and accounting as the four key functions to have represented in a supplier selection team. In the case studies, the senior staff member in each department was selected based on their experience and knowledge about the various business functions of the company. However, in the elevator company, one more staff in the purchasing department was also selected. In the electric boiler company only three staff were available for questioning, but the member of staff from manufacturing operations was also responsible for the engineering function. The interviews with the staff required visits to the companies to gather data "face to face". During each interview, the specific terminology of the decision criteria and the components of the elevator or boiler were explained to the staff if necessary. Special care was taken to avoid the pitfall of using leading questions when asking the staff for their evaluations.

9. Implementation using the AHP

Staff at the electric boiler company and the elevator company were the "evaluators" for the purposes of the AHP, which was implemented using the Expert Choice (2004) software. The AHP is explained in detail by Saaty and Vargas (2001) and succinctly by Drake (1998). An introduction in the context of purchasing strategy and the electric boiler and elevator applications is given here. In summary, it proceeds as follows:

- Select the criteria and their sub-criteria (measures) according to which the components are to be prioritised; these encapsulate the competitive priorities of the business.
- Weight the relative importance of the criteria using pair-wise comparisons based on a "1 to 9" relative importance scale as described in the following.
- Weight the relative importance of the sub-criteria within each criterion using pair-wise comparisons and the "1 to 9" scale and multiply these weights by their parent criteria weights to get global sub-criteria weights.
- Score the impact of each component on each sub-criterion using the direct rating scale described in the following and weight these scores using the sub-criterion weights before summing to give an overall score for the component.

The goal is placed at Level 1 of the AHP hierarchy, as shown in Figure 3. The goal in this application is the scoring of each component's impact on the competitive priorities of the business. Level 2 of the hierarchy contains the competitive priorities (ranking criteria) introduced previously. Level 3 contains the sub-criteria that are used to measure the criteria. The relative importance of the criteria and sub-criteria to the business and the parent criteria respectively are rated using pair-wise comparisons. Level 4 of the hierarchy contains the rating scale for assessing the impact of individual components of the elevator on the sub-criteria. This is different from the usual AHP approach in that an absolute measurement is assigned to each sub-criterion for each component to be purchased, instead of pair-wise comparisons of the components on the basis of each sub-criterion. This absolute (or direct) measurement is used because there would be an intractable number of pair-wise comparisons to perform. In the electric boiler case study presented here, there are 13 components to be rated against the 12 strategic priority measures. This would result in ${}_{13}C_2 = 13!/2!(13-2)! = 78$ pair-wise comparisons for each of the 12 measures, giving a total of $78 \times 12 = 936$ comparisons. Absolute measurement reduces this to $13 \times 12 = 156$ measurements. This difference would grow very rapidly with increases in the number of components. This direct approach has been used in supplier selection (Chan and Chan, 2004; Tam and Tummala, 2001). The last level of the hierarchy consists of the components to be evaluated.

The nine-point scale in Table IV, suggested by Saaty and Vargas (2001), is used in making the pair-wise comparisons of the criteria and sub-criteria. For example, if an evaluator decides that quality is moderately more important than time, then the former is rated "3" and the latter "1/3" in this pair-wise comparison. Within each criterion, the sub-criteria are compared pair-wise to establish their relative importance to their parent criterion. Tables V-IX show the pair-wise comparison matrices for the competitive priorities produced by Evaluator-1 in the electric boiler company, one for the criteria and one for each of the four groups of sub-criteria within the criteria.

There is the possibility of inconsistency in the pair-wise comparisons. For example, an evaluator may rate quality as "7" against cost, cost as "7" against time and time as "7" against quality. This is inconsistent as the first two "7"s imply

Table III The electric boiler and elevator product manufacturers

	Electric boiler company	Elevator company
Product life cycle	More than two years	One to two years
Product variety	Ten to 50 variants	More than 100 variants
Demand	Predictable	Unpredictable
Profit margins (%)	Ten to 20	20 to 50
Average stockout rate (%)	Two to ten	Ten to 40
Order winner	Cost	Flexibility
Level of customisation	Standardisation	Tailored customisation
Manufacturing strategy	MTS	MTO
Supply chain	Lean	Agile

Figure 3 AHP model for measuring impact of components on strategic priorities

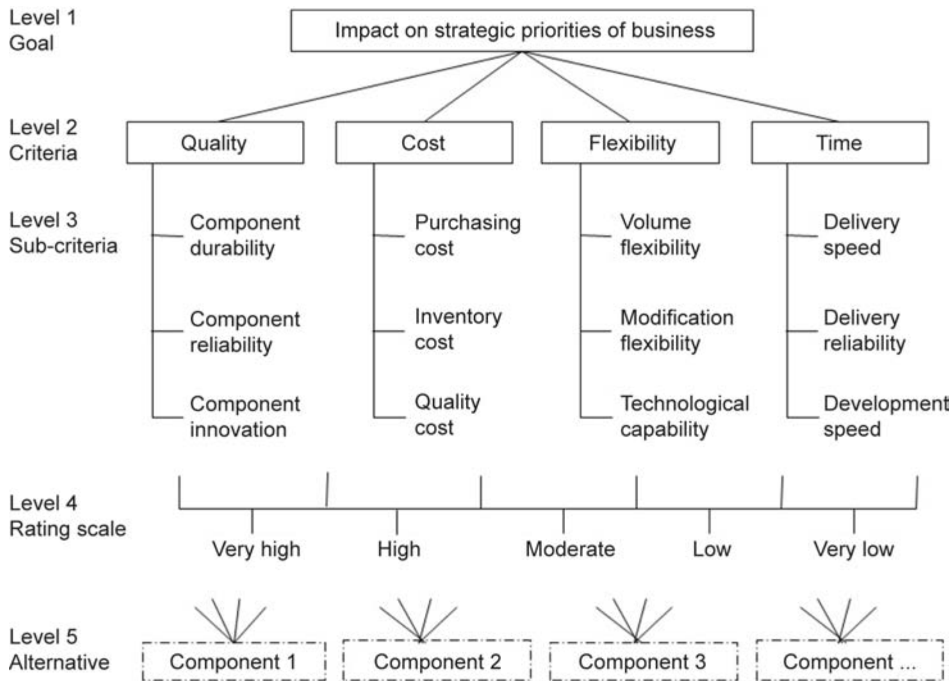


Table IV One to nine scale for AHP preference

Intensity of importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance	Experience and judgement slightly favour one over another
5	Strong importance	Experience and judgement strongly favour one over another
7	Very strong importance	An activity is strongly favoured and its dominance is demonstrated in practice
9	Absolute importance	Importance of one over another affirmed on the highest possible order
2, 4, 6, 8	Intermediate values	Used to represent compromise between the priorities listed above
Reciprocals of above non-zero numbers	If activity *i* has one of the above non-zero numbers assigned to it when compared with activity *j*, then *j* has the reciprocal value when compared with i	

Table V Pair-wise comparison matrix of the competitive priority Goal by Evaluator-1 in the electric boiler manufacturer

Goal	Quality	Cost	Flexibility	Time
Quality	1	2	4	4
Cost	1/2	1	4	4
Flexibility	1/4	1/4	1	2
Time	1/4	1/4	1/2	1
				CR = 0.01

Note: CR, consistency ratio

that quality should be rated more highly than time. To understand Saaty's (1980) treatment of inconsistency, let a_{ij} denote the comparison of criterion i against criterion j, the element of the comparison matrix at row i, column j. A matrix is then called "consistent" if $a_{ij} \times a_{jk} = a_{ik}$, for all i, j, k.

Based on this, Saaty then shows that for a pair-wise comparison matrix of size $(n \times n)$ to be "absolutely consistent", it must have one positive eigenvalue $\lambda_{\max} = n$, while all other eigenvalues equal zero. In the real world, human evaluators do not usually achieve absolute consistency; so to be pragmatic, Saaty introduces the consistency index (CI) to measure the "closeness to absolute consistency":

$$\mathrm{CI} = (\lambda_{\max} - n)/(n - 1) \tag{1}$$

There is then a need to interpret the value of CI to determine if it is acceptable, i.e. sufficiently close to zero. Saaty's basis for making this decision starts with the premise that, if one has little or no information about the factors being compared, then judgments will appear to be random (Forman and Selly, 2001). Saaty then introduced the consistency ratio (CR) to assess whether a matrix is sufficiently consistent or not. This is the ratio of the CI to the random index (RI), where RI is the CI of a matrix of comparisons generated randomly:

$$\mathrm{CR} = \mathrm{CI}/\mathrm{RI} \tag{2}$$

The rule of thumb applied by Saaty and others (e.g. Forman and Selly (2001), Liu *et al.* (2008) and Ting and Cho (2008))

Table VI Pair-wise comparison matrix of the competitive priority Quality by Evaluator-1 in the electric boiler manufacturer

Quality	Component durability	Component reliability	Component innovation
Component durability	1	2	3
Component reliability	1/2	1	2
Component innovation	1/3	1/2	1
			CR = 0.01

Note: CR, consistency ratio

Table VII Pair-wise comparison matrix of the competitive priority Cost by Evaluator-1 in the electric boiler manufacturer

Cost	Purchasing cost	Inventory cost	Quality cost
Purchasing cost	1	4	5
Inventory cost	1/4	1	1
Quality cost	1/5	1	1
			CR = 0.01

Note: CR, consistency ratio

Table VIII Pair-wise comparison matrix of the competitive priority Flexibility by Evaluator-1 in the electric boiler manufacturer

Flexibility	Volume flexibility	Modification flexibility	Technological capability
Volume flexibility	1	3	3
Modification flexibility	1/3	1	1
Technological capability	1/3	1	1
			CR = 0.00

Note: CR, consistency ratio

Table IX Pair-wise comparison matrix of the competitive priority Time by Evaluator-1 in the electric boiler manufacturer

Time	Delivery speed	Delivery reliability	Development speed
Delivery speed	1	1/3	2
Delivery reliability	3	1	5
Development speed	$\frac{1}{2}$	1/5	1
			CR = 0.00

Note: CR, consistency ratio

is that CI < RI/10 to be acceptable, i.e. CR < 0.1. Each pair-wise comparison matrix in Tables V-IX is presented with its CR and these satisfy this consistency test.

As suggested by Saaty and Vargas (2001), the geometric mean (the nth root of the product of n items), rather than the arithmetic mean, is used to consolidate the pair-wise comparison matrices of the individual evaluators. This yields the five "consensus matrices" in Tables X-XIV for the electric boiler and Tables XV-XIX for the elevator. The next step is to compute the "priority vectors" to define the relative priorities of the criteria and sub-criteria (the final columns of Tables X-XIX). There are potentially many ways in which this might be done. However, Saaty's consistency principle that $a_{ij} \times a_{jk} = a_{ik}$ and subsequent argument for using the special case of the consistent matrix formed by elements $a_{ij} = w_i/w_j$, where w_i and w_j are the elements of the priority weight vector corresponding to criteria i and j (i.e. their priorities), leads to the following method that is used here. In terms of matrix algebra, a priority vector is computed as the normalised, principal (largest) eigenvector of the consensus matrix of pair-wise comparisons. This calculation is complex, but is normally executed using proprietary software. However, there are simpler methods for calculating an approximate solution that can be implanted readily in a spreadsheet, e.g. Drake (1998).

Table X Geometric mean of pair-wise comparison matrix of the competitive priority Goal for all evaluators for the electric boiler manufacturer

Goal	Quality	Cost	Flexibility	Time	Priority weight
Quality	1.0	1.3	3.9	3.3	0.42
Cost	0.8	1.0	1.0	2.9	0.35
Flexibility	0.3	0.3	3.3	1.3	0.12
Time	0.3	0.3	0.8	1.0	0.11
					CR = 0.01

Note: CR, consistency ratio

The priority vectors in Tables X-XIX are used to produce the overall or global weights for the sub-criteria in Table XX. The corresponding criterion and sub-criterion weights are multiplied to give a global weight for each sub-criterion, so that the importance or weight of a sub-criterion is measured by its importance to its parent criterion weighted by the importance of the parent criterion to the business strategy. For example, looking at Table XX, the electric boiler company has generated a weight of 0.42 for quality when rating it against the other criteria (flexibility, cost and time). Within quality, a weight of 0.48 has been assigned to component durability when rating it against component reliability and component innovation. So the overall or global weight for component durability is $0.42 \times 0.48 = 0.202$. This is the weight given to this sub-criterion relative to all the sub-criteria across all the criteria and the sum of all such global sub-criterion weights is then 1.

In the second stage, evaluators were requested to use absolute measurement to rate the strength of the impact of the individual components on the sub-criteria using the five-point scale (VH = very high; H = high; M = medium; L = low; VL = very low) suggested by Tam and Tummala (2001). Table XXI gives the ratings of several components by Evaluator-1 in the electric boiler company. Table XXII shows the normalised weights calculated for the five-point scale using the AHP procedure described previously.

For each component, the results obtained with the five-point rating scale are multiplied by the global weights of the sub-criteria. This process is illustrated in Table XXIII for the Internal steel sheet component in the electric boiler. For example, the global weight for component durability is 0.202 (from Table XX) and the impact of the control panel on durability has been assessed as high, which equates to a weight of 0.26 (from Table XXII). So the score for Internal steel sheet in respect of durability is $0.202 \times 0.26 = 0.052$. The total score for each component is normalised by dividing

Table XI Geometric mean of pair-wise comparison matrix of the competitive priority Quality for all evaluators for the electric boiler manufacturer

Quality	Component durability	Component reliability	Component innovation	Priority weight
Component durability	1.0	1.3	3.3	0.48
Component reliability	0.8	1.0	2.6	0.38
Component innovation	0.3	0.4	1.0	0.14
				CR = 0.00

Note: CR, consistency ratio

Table XII Geometric mean of pair-wise comparison matrix of the competitive priority Cost for all evaluators for the electric boiler manufacturer

Cost	Purchasing cost	Inventory cost	Quality cost	Priority weight
Purchasing cost	1.0	3.3	3.1	0.61
Inventory cost	0.3	1.0	1.3	0.21
Quality cost	0.3	0.8	1.0	0.18
				CR = 0.01

Note: CR, consistency ratio

Table XIII Geometric mean of pair-wise comparison matrix of the competitive priority Flexibility for all evaluators for the electric boiler manufacturer

Flexibility	Volume flexibility	Modification flexibility	Technological capability	Priority weight
Volume flexibility	1.0	2.6	2.6	0.57
Modification flexibility	0.4	1.0	1.3	0.23
Technological capability	0.4	0.8	1.0	0.20
				CR = 0.01

Note: CR, consistency ratio

Table XIV Geometric mean of pair-wise comparison matrix of the competitive priority Time for all evaluators for the electric boiler manufacturer

Time	Delivery speed	Delivery reliability	Development speed	Priority weight
Delivery speed	1.0	0.4	2.3	0.29
Delivery reliability	2.3	1.0	3.6	0.57
Development speed	0.4	0.3	1.0	0.14
				CR = 0.02

Note: CR, consistency ratio

Table XV Geometric mean of pair-wise comparison matrix of the competitive priority Goal for all evaluators for the elevator manufacturer

Goal	Quality	Cost	Flexibility	Time	Priority weight
Quality	1.0	2.2	0.8	3.3	0.32
Cost	0.5	1.0	0.4	2.6	0.18
Flexibility	1.3	2.4	1.0	4.3	0.41
Time	0.3	0.4	0.2	1.0	0.09
					CR = 0.01

Note: CR, consistency ratio

by the sum of the total scores across all the components, so that they sum to 1. Looking at Table XXIII, the total score for the control panel is $0.052 + 0.041 + \cdots + 0.001 = 0.294$. The sum of the total scores across all the components was calculated as 1.937. So the normalised total score for the control panel is $0.294/1.937 = 0.152$. The lean and agile scores are calculated by adding the quality and cost scores and the flexibility and time scores respectively. These are then normalised using the same calculation as mentioned previously, i.e. dividing by 1.937. The normalised, lean and agile scores for each component from each evaluator are then combined using the geometric mean to give the results in the final two columns of Table XXIV for the electric boiler and Table XXV for the elevator.

The standardised lean and agile scores for the components are calculated using equations (3-4) and used to position the components in the lean and agile purchasing portfolio model:

$$\mathrm{ZL_i} = (\mathrm{yl_i} - \mathrm{y_{min}})/(\mathrm{y_{max}} - \mathrm{y_{min}}) \quad (3)$$

$$\mathrm{ZA_i} = (\mathrm{ya_i} - \mathrm{y_{min}})/(\mathrm{y_{max}} - \mathrm{y_{min}}) \quad (4)$$

where $\mathrm{ZL_i}$ ($\mathrm{ZA_i}$) is the standardised lean (agile) score of component i; $\mathrm{yl_i}(\mathrm{ya_i})$ is the mean normalised lean (agile) score

Table XVI Geometric mean of pair-wise comparison matrix of the competitive priority Quality for all evaluators for the elevator manufacturer

Quality	Component durability	Component reliability	Component innovation	Priority weight
Component durability	1.0	1.3	2.9	0.47
Component reliability	0.8	1.0	2.4	0.37
Component innovation	0.3	0.4	1.0	0.16
				CR = 0.00

Note: CR, consistency ratio

Table XVII Geometric mean of pair-wise comparison matrix of the competitive priority Cost for all evaluators for the elevator manufacturer

Cost	Purchasing cost	Inventory cost	Quality cost	Priority weight
Purchasing cost	1.0	4.5	2.4	0.61
Inventory cost	0.2	1.0	0.5	0.13
Quality cost	0.4	2.0	1.0	0.26
				CR = 0.00

Note: CR, consistency ratio

Table XVIII Geometric mean of pair-wise comparison matrix of the competitive priority Flexibility for all evaluators for the elevator manufacturer

Flexibility	Volume flexibility	Modification flexibility	Technological capability	Priority weight
Volume flexibility	1.0	0.3	0.5	0.15
Modification flexibility	3.4	1.0	2.2	0.56
Technological capability	2.2	0.5	1.0	0.29
				CR = 0.01

Note: CR, consistency ratio

Table XIX Geometric mean of pair-wise comparison matrix of the competitive priority Time for all evaluators for the elevator manufacturer

Time	Delivery speed	Delivery reliability	Development speed	Priority weight
Delivery speed	1.0	0.8	3.1	0.38
Delivery reliability	1.3	1.0	3.6	0.49
Development speed	0.3	0.3	1.0	0.13
				CR = 0.00

Note: CR, consistency ratio

of component i; $y_{\min}$ is the minimum mean normalised score across both the lean and agile scores for all components; $y_{\max}$ is the maximum mean normalised score across both the lean and agile scores for all components.

The standardisation transforms the mean normalised scores onto the 0 to 1 scale used for the axes of the purchasing portfolio model. The lowest mean normalised score becomes 0 and the highest becomes 1, with the other scores scaled in between. For example, for the electric boiler company in Table XXIV the mean scores of lean and agile for the Diffuser are $\mathrm{yl}_1 = 0.045$, $\mathrm{ya}_1 = 0.016$, $\mathrm{y}_{\min} = 0.008$, $\mathrm{y}_{\max} = 0.119$. So, the standardised lean score for the Diffuser is $\mathrm{ZL}_1 = (0.045 - 0.008)/(0.119 - 0.008) = 0.333$ and the standardised agile score is $\mathrm{ZA}_1 = (0.016 - 0.008)/(0.119 - 0.008) = 0.072$. The standardised scores of lean and agile in Figures 4 and 5 are used to position each component in the lean and agile purchasing portfolio models in Figure 6.

10. Analysis of results

Table XXVI presents the lean and agile weights for the two manufacturers. It shows that for the "lean" electric boiler manufacturer the lean characteristics (quality and cost) are weighted more heavily than the agile characteristics (flexibility and time) in the ratio 77 to 23 per cent. However, the "agile" elevator manufacturer has weighted both equally (50 per cent). This is a most significant result as before the analysis it was thought by using Fisher's (1997) reasoning that the business should focus primarily on agility.

Since the electric boiler must be extremely safe and reliable, quality (0.42) is understandably the supreme strategic priority. However, as competition is primarily on cost and profit margins are low, it is understandable that cost (0.35) is the second highest priority in Table XXVI. These two weights agree with the electric boiler being classed as a functional product suited to lean supply, so that its purchasing strategies should focus on leanness. The electric boiler is indeed

Table XX Combined criteria and sub-criteria weights in two manufacturers

Company	Competitive priority	Local weight	Competitive priority measures	Local weight	Global weight	Rank
Electric boiler company	Quality	0.42	Component durability	0.48	0.202	2
			Component reliability	0.38	0.160	3
			Component innovation	0.14	0.059	8
	Cost	0.35	Purchasing cost	0.61	0.214	1
			Inventory cost	0.22	0.077	4
			Quality cost	0.17	0.060	7
	Flexibility	0.12	Volume flexibility	0.57	0.068	5
			Modification flexibility	0.23	0.028	10
			Technological capability	0.20	0.024	11
	Time	0.11	Delivery speed	0.29	0.032	9
			Delivery reliability	0.57	0.063	6
			Development speed	0.14	0.015	12
	Total	1.00	Total		1.000	
Elevator company	Quality	0.32	Component durability	0.47	0.150	2
			Component reliability	0.37	0.118	4
			Component innovation	0.16	0.051	7
	Cost	0.18	Purchasing cost	0.61	0.110	5
			Inventory cost	0.13	0.023	11
			Quality cost	0.26	0.047	8
	Flexibility	0.41	Volume flexibility	0.15	0.062	6
			Modification flexibility	0.56	0.230	1
			Technological capability	0.29	0.119	3
	Time	0.09	Delivery speed	0.38	0.034	10
			Delivery reliability	0.49	0.044	9
			Development speed	0.13	0.012	12
	Total	1.00	Total		1.000	

Table XXI Example absolute ratings given by Evaluator-1 to some of the components in the electric boiler

			Evaluator-1	
Competitive priority	**Competitive priority measures/component rating**	**Internal steel sheet**	**Lagging**	**Rubber packing**
Quality	Component durability	H	M	M
	Component reliability	H	H	L
	Component innovation	H	L	VL
Cost	Purchasing cost	VH	M	VL
	Inventory cost	H	M	VL
	Quality cost	L	VL	VL
Flexibility	Volume flexibility	H	H	L
	Modification flexibility	M	H	VL
	Technological capability	H	L	L
Time	Delivery speed	H	M	L
	Delivery reliability	H	M	L
	Development speed	VL	L	VL

Notes: VH = very high; H = high; M = medium; L = low; VL = very low

comprised entirely of standard components and made-to-stock.

In contrast, an elevator is comprised of both standard and specific components, and it is customised to meet the needs of individual customers through a make-to-order strategy. Consequently, flexibility (0.41) is quite naturally the highest competitive priority. However, quality (0.32) still has a high priority for safety reasons, i.e. an elevator is potentially very dangerous. Although the elevator has characteristics of an innovative product, which implies using agile supply, the elevator firm should focus on both lean and agile characteristics as it has weighted them equally at 50 per cent. This is telling us more than the basic Fisher principle that innovative products are suited to agile supply, demonstrating a significant contribution of the new portfolio model.

It is noted that for the elevator, time has a relatively low priority even though the elevator is made-to-order. The reason for this is the over-riding importance of flexibility and quality. The manufacturer and the customer place less emphasis on time than actually being able to satisfy an order (flexibility) and the criticality of safety (quality) in this application. This demonstrates that far greater importance may be placed on one of each pair of priorities, time-flexibility and cost-quality, measuring the need for agility or leanness respectively. For example, in some agile supply situations time could become the critical competitive factor rather than flexibility if it is relatively easy to meet variable product requirements. This is not the case in the South Korean elevator industry.

Figures 4 and 5 show the components' standardised lean and agile scores for the electric boiler and elevator respectively. These reveal very different patterns between the two products. In the case of the electric boiler, the standardised lean scores are much higher than the standardised agile scores; which are very low, for all components. In contrast, the elevator has some components with high standardised agile scores, and all but one of these have relatively higher lean scores also, making them suited to leagile supply.

Figure 6 shows the positioning of components within the lean and agile purchasing portfolio models for both companies. As mentioned previously, the electric boiler has no component in the high agility categories, which is in accord with the electric boiler being a functional product; it has several non-strategic items and a cluster of lean items. In contrast, the elevator has one component in the agile category and several in the leagile category. The presence of several leagile items means that although the elevator is an innovative product fundamentally suited to agile supply, it is still important to improve cost and quality for some components that are also important to flexibility and time. Both companies have a very large concentration of components in the non-strategic category, as one would expect in the corresponding C-category when using traditional ABC analysis.

Table XXII Pair-wise comparison judgment matrix for five-point rating scale

Rating scale	VH	H	M	L	VL	Priority weight
Very high (VH)	1	3	5	7	9	0.51
High (H)	1/3	1	3	5	7	0.26
Moderate (M)	1/5	1/3	1	3	5	0.13
Low (L)	1/7	1/5	1/3	1	3	0.06
Very low (VL)	1/9	1/7	1/5	1/3	1	0.04

11. Conclusion

Purchasing strategy must be designed to match and thereby support business strategy; the literature and logical argument have been used to support this conclusion. Furthermore, it has been argued that this alignment needs consideration at the component level of products as the strength of the impact of purchases on the different competitive priorities will vary

Table XXIII Calculation of overall score for the internal steel sheet component in the electric boiler by Evaluator-1

Competitive priority measures	Global weight[a]	Internal steel sheet scoring: Rate	Rating weight[b]	Global weight × Rating weight
Quality				
Component durability	0.202	H	0.26	0.052
Component reliability	0.160	H	0.26	0.041
Component innovation	0.059	H	0.26	0.015
Cost				
Purchasing cost	0.214	VH	0.51	0.109
Inventory cost	0.077	H	0.26	0.020
Quality cost	0.060	L	0.06	0.004
Flexibility				
Volume flexibility	0.068	H	0.26	0.018
Modification flexibility	0.028	M	0.13	0.004
Technological capability	0.024	H	0.26	0.006
Time				
Delivery speed	0.032	H	0.26	0.008
Delivery reliability	0.063	H	0.26	0.016
Development speed	0.015	VL	0.04	0.001
Total score				0.294
Lean (quality and cost) score				0.241
Agile (flexibility and time) score				0.053
Normalized total score = Total score/sum of total score across all components				0.152
Normalized lean score = Lean score/sum of total score across all components				0.125
Normalized agile score = Agile score/sum of total score across all components				0.027

Notes: [a]See Table XX; [b]Table XXII

Table XXIV Summary of normalized scores of lean and agile of all components in the electric boiler manufacturer

	Evaluator-1		Evaluator-2		Evaluator-3		Mean score	
Electric boiler component	Lean	Agile	Lean	Agile	Lean	Agile	Lean	Agile
Diffuser	0.041	0.013	0.039	0.017	0.056	0.019	0.045	0.016
Electric control box	0.117	0.031	0.117	0.029	0.105	0.026	0.113	0.029
External steel sheet	0.096	0.028	0.089	0.018	0.083	0.025	0.089	0.023
Floating valve	0.019	0.006	0.027	0.007	0.024	0.011	0.023	0.008
Heater	0.086	0.027	0.080	0.022	0.068	0.020	0.078	0.023
Internal steel sheet	0.125	0.027	0.131	0.024	0.103	0.028	0.119	0.026
Lagging	0.055	0.024	0.047	0.024	0.060	0.016	0.054	0.021
Magnesium bar	0.056	0.017	0.042	0.021	0.060	0.021	0.052	0.020
Rubber packing	0.025	0.008	0.024	0.009	0.025	0.013	0.025	0.010
Sensor	0.050	0.013	0.051	0.012	0.056	0.011	0.052	0.012
Socket	0.041	0.017	0.042	0.022	0.060	0.022	0.047	0.020
Thermometer	0.023	0.008	0.040	0.012	0.035	0.011	0.032	0.010
Thermostat	0.037	0.010	0.041	0.011	0.037	0.011	0.038	0.011
Total	0.771	0.229	0.770	0.230	0.768	0.232	0.769	0.231

Table XXV Summary of normalized scores of lean and agile of all components in the elevator manufacturer

	Evaluator-1		Evaluator-2		Evaluator-3		Evaluator-4		Evaluator-5		Mean score	
Elevator component	Lean	Agile	Lean	Agile	Lean	Agile	Lean	Agile	Lean	Agile	Lean	Agile
Brake	0.033	0.030	0.024	0.026	0.032	0.031	0.024	0.032	0.035	0.017	0.029	0.028
Buffers	0.014	0.008	0.019	0.015	0.015	0.009	0.012	0.010	0.011	0.011	0.013	0.011
Car set	0.046	0.037	0.039	0.039	0.047	0.047	0.047	0.041	0.052	0.049	0.045	0.043
Compensating chain	0.015	0.011	0.019	0.015	0.016	0.011	0.018	0.013	0.017	0.014	0.017	0.013
Control panel	0.039	0.043	0.029	0.046	0.053	0.045	0.033	0.043	0.037	0.046	0.039	0.045
Counterweights	0.015	0.009	0.019	0.015	0.015	0.009	0.013	0.010	0.011	0.011	0.014	0.011
Door operator	0.025	0.022	0.019	0.026	0.026	0.022	0.023	0.023	0.027	0.022	0.023	0.023
Door safety devices	0.025	0.021	0.019	0.026	0.023	0.013	0.023	0.020	0.023	0.015	0.023	0.018
Governor	0.029	0.035	0.022	0.022	0.019	0.026	0.020	0.032	0.029	0.020	0.024	0.027
Guide rails	0.026	0.019	0.022	0.019	0.026	0.018	0.019	0.020	0.029	0.022	0.023	0.019
Guide shoes	0.013	0.012	0.019	0.015	0.014	0.013	0.018	0.013	0.015	0.015	0.016	0.013
Interlock devices	0.024	0.012	0.019	0.019	0.015	0.019	0.019	0.014	0.021	0.015	0.020	0.016
Limit switch	0.012	0.012	0.019	0.015	0.013	0.013	0.018	0.013	0.009	0.015	0.014	0.013
Load weighing devices	0.012	0.011	0.019	0.013	0.013	0.011	0.018	0.013	0.014	0.014	0.015	0.012
Motor generator	0.035	0.043	0.029	0.026	0.037	0.045	0.031	0.033	0.037	0.041	0.034	0.038
Operation fixtures	0.022	0.036	0.021	0.026	0.024	0.033	0.025	0.031	0.020	0.037	0.022	0.032
Rail brackets	0.012	0.012	0.019	0.015	0.013	0.013	0.018	0.014	0.014	0.015	0.015	0.014
Roller guides	0.012	0.012	0.019	0.015	0.013	0.013	0.018	0.013	0.014	0.015	0.015	0.013
Rope brake	0.014	0.013	0.019	0.015	0.016	0.014	0.020	0.014	0.016	0.015	0.017	0.014
Ropes	0.025	0.022	0.022	0.015	0.024	0.026	0.020	0.023	0.027	0.017	0.023	0.020
Safety gear	0.012	0.012	0.019	0.015	0.013	0.013	0.018	0.013	0.014	0.015	0.015	0.013
Traction machine	0.035	0.043	0.029	0.026	0.037	0.045	0.031	0.044	0.037	0.041	0.034	0.040
Travelling cable	0.015	0.011	0.019	0.015	0.016	0.012	0.018	0.014	0.017	0.012	0.017	0.012
Total	0.510	0.486	0.503	0.479	0.508	0.492	0.504	0.496	0.502	0.498	0.505	0.495

across the components. Fisher (1997) classified products as functional or innovative to determine whether they are suited to lean or agile supply. This classification has been extended here to the component level and the leagile and non-strategic supply options have been added. The classification depends on the impact a component has on the four competitive priorities; cost, quality, time and flexibility.

Purchasing portfolio models, most notably based on the Kraljic matrix, have been adopted in practice to determine the most appropriate purchasing strategy for a particular item. However, the Kraljic-type dimensions fail to consider whether the item is functional or innovative and thereby suited to lean or agile supply. The lean and agile purchasing portfolio model presented here has addressed this deficiency. This model is based on two dimensions; leanness and agility. The positioning of a purchase according to its level of impact on leanness and agility has been achieved by the application of the AHP to quantify the impact perceived by company staff.

The lean and agile component model has been applied to two South Korean businesses; an electric boiler manufacturer

Supply Chain Management: An International Journal
Volume 18 · Number 1 · 2013 · 3–20

Figure 4 Standard lean and agile scores of components in the electric boiler

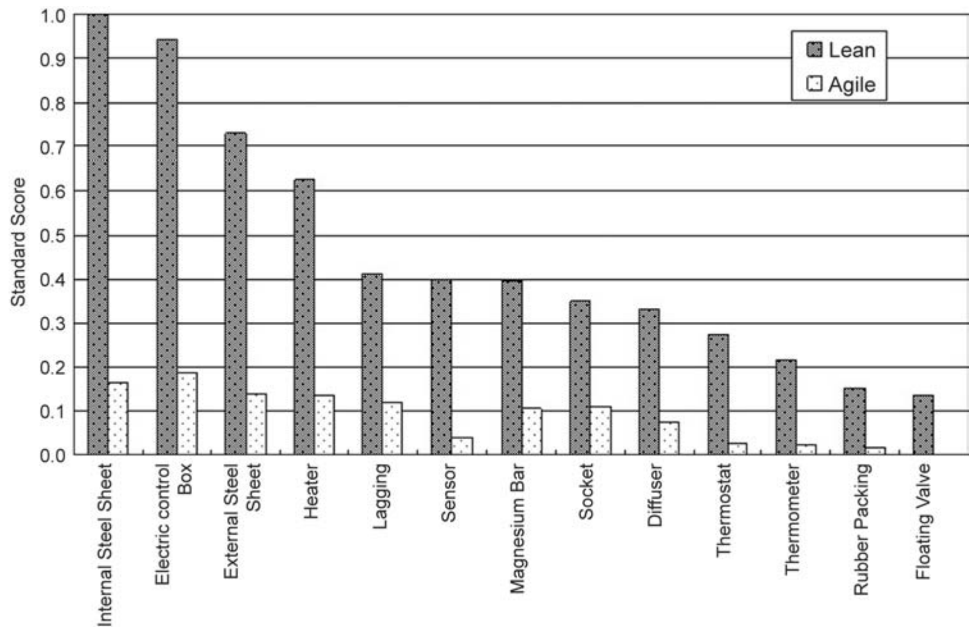
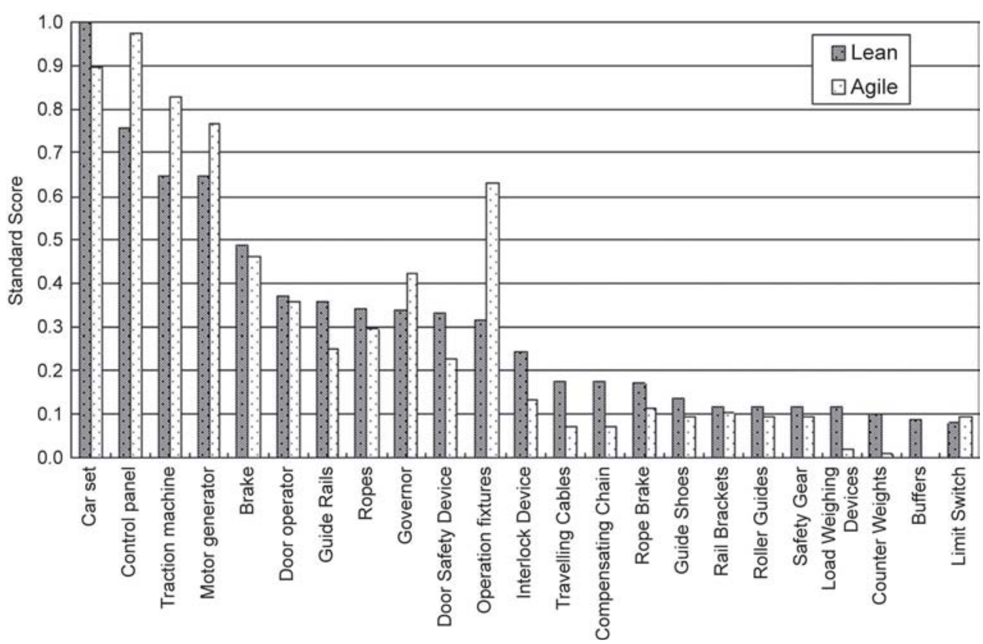


Figure 5 Standard lean and agile scores of components for the elevator



and an elevator manufacturer. The case studies have shown how different purchasing strategies should be adopted across different purchased components according to their impact on the competitive priorities of the business. As the electric boiler is a functional product, while the elevator is an innovative product, the case studies have shown also how this varies between products suited to lean and agile supply respectively. In the case of the electric boiler the components have been split between the lean and non-strategic categories as had been expected for a highly functional product. However, for the innovative product, all but one of the strategically important components have been placed in the leagile category with only one being placed in the pure agile category. This demonstrates that for an innovative product the benefits of lean supply may still need to be exploited for some components due to their impact on quality and/or cost in addition to flexibility and/or time. This is achieved through leagile supply, so that the necessary agility is achieved also. This would have been missed by just following Fisher's principle of applying lean or agile for functional and innovative products respectively. This addresses the concern

Figure 6 Lean and agile portfolio models for the two manufacturers

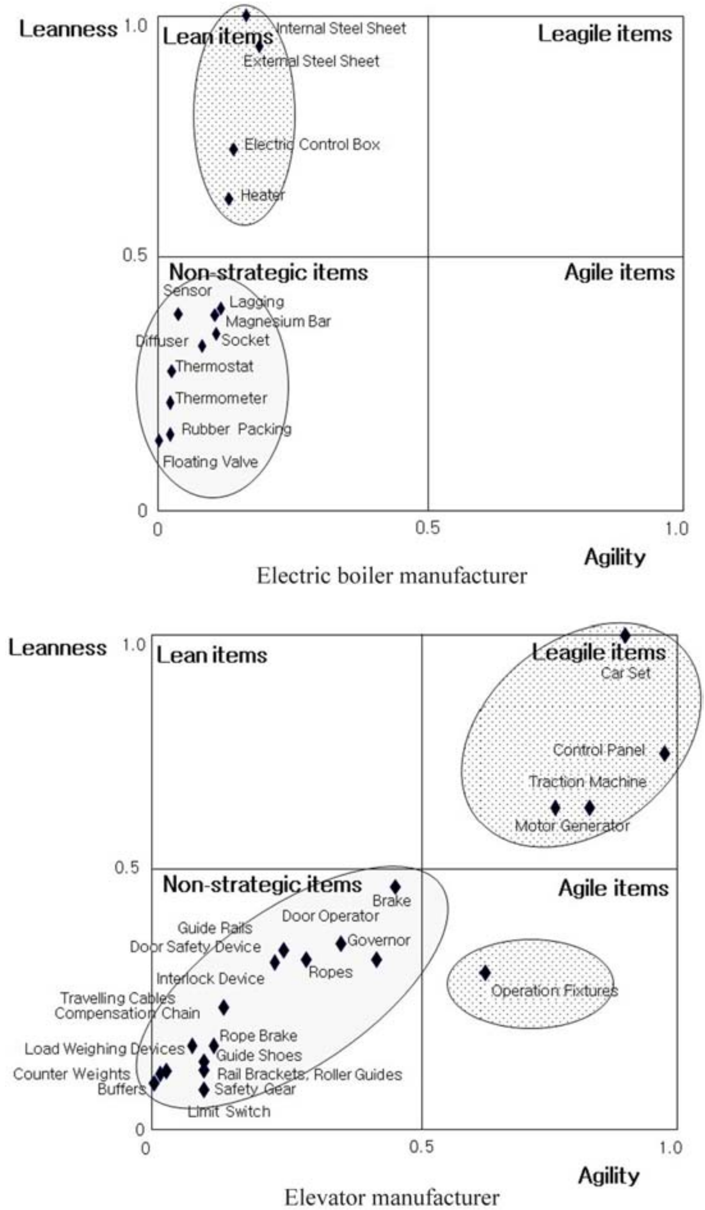


Table XXVI Weights of lean and agile characteristics in the two manufacturers

Strategic priority	Electric boiler Local weight[a]	Elevator Local weight[a]
Lean characteristics	0.77	0.50
Quality factors	0.42	0.32
Cost factors	0.35	0.18
Agile characteristics	0.23	0.50
Flexibility factors	0.12	0.41
Time factors	0.11	0.09

Note: [a]Local weights of factors from Table XX

Lo and Power (2010) raised about how leagile fits with Fisher's model.

The new model has been tested on only two case studies, which limits the ability to generalise the findings. Future work will use the lean and agile purchasing portfolio model in research and knowledge exchange activities with other industrial partners to further develop and test its efficacy.

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