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A model for customer-focused objective-based performance evaluation of logistics service providers

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Abstract

Purpose – This paper aims to propose a customer-oriented, objective-based model for evaluating the performance of logistics service providers (LSPs).

Design/methodology/approach – The study develops an appropriate customer-oriented, objective-based measurement model for LSPs on conceptual grounds. The paper illustrates the application in the form of a case study of a Taiwanese electronics manufacturer.

Findings – Satisfactory results are obtained in demonstrating the application of the model. Compared with the previous model used by the case company, the new model produced sensitive, accurate, and effective manufacturing performance rating results for different achievement levels.

Practical implications – The proposed LSP performance-rating model can be applied by a variety of manufacturers to assess all kinds of LSPs in various industries. The proposed model can assist manufacturers in selecting the best LSP and integrating LSP capabilities to develop an appropriate quality-and-profit improvement program using customer-specific requirements.

Originality/value – This paper proposes an original model to solve the problem of multiple measurements in assessing an LSP, taking into account the total cost of logistics (including net price, delivery, quality, service, and so on).

Keywords Performance measurement (quality), Customer satisfaction, Cost effectiveness, Distribution management

Paper type Research paper

1. Introduction

The increasing competition of globalised business has prompted many firms to improve their logistics management as a part of their corporate strategy for cost and service advantages (McGinnis and Kohn, 2002). With a view to introducing their new products and services to the market more rapidly and efficiently, many manufacturers and retailers are now seeking to outsource their logistics activities to logistics service providers (LSPs) (Lieb and Miller, 2002).

In general terms, an LSP can be defined as a provider of logistics services that performs all or part of a client company's logistics function (Coyle *et al.*, 1996; Delfmann *et al.*, 2002). In most cases, this consists of the LSP at least managing and operating the transportation and warehousing functions on behalf of the client. In addition, an LSP can provide other services – including materials-management services (such as inventory management), information-related services (such as tracking and tracing), and value-added services (such as secondary assembly) (Berglund *et al.*, 1999). Indeed, to satisfy the increasing demand for one-stop services, many LSPs have significantly broadened the scope of their activities to include these and other services (Murphy and Daley, 2001). In making decisions about how they should expand their service capabilities and improve their service performance (Lai,

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2004), LSPs recognise that their competitiveness ultimately depends on the extent to which they add value to the bottom line of their clients. To achieve this, LSPs must work cooperatively with their clients, learn their business practices, and introduce appropriate innovations that improve the performance of the supply chain (Panayides and So, 2005). Ensuring operational quality at each stage of the customers' process will increase the likelihood of satisfying the end-customer (Jang *et al.*, 2003).

Customer satisfaction is commonly acknowledged as one of the most important parameters of system success (Chen *et al.*, 2000; Roh *et al.*, 2005). This study therefore attempts to: identify the critical factors for customer satisfaction in logistics services; and develop an instrument for measuring these factors. In the literature on this subject, most authors have studied the relationship between the LSP and the manufacturer, or that between the LSP and the customer; moreover, most studies have adopted "price" as the cost of logistics in their models. In general, the majority of studies have ignored the various quality factors and constraints that exist at different stages in the process; in doing so, they have ignored numerous consequential costs that could ultimately cause huge potential loss (Ernst and Young, 1992). In contrast, this study proposes a model that incorporates a simple linear-programming weighted-point approach to the solution of the problem of multiple measurements. In doing so, the model takes into account the total cost of logistics – including net price, delivery costs, quality costs, service costs, and so on. The model then proposes a performance-rating system for LSPs utilising appropriate objective-based measures from the perspective of customer satisfaction. The utility of the model is then illustrated using an actual case application.

2. Literature review

As previously noted, LSPs perform logistics activities for a customer, either completely or in part (Delfmann *et al.*, 2002; Lai *et al.*, 2004). These functions can include traditional logistics activities (such as transport, warehousing, and packaging) and less-conventional activities (such as customs clearance, billing, and tracking and tracing) (Krauth *et al.*, 2005). In general terms, an LSP thus deals with the logistics of the delivery of inputs from suppliers to the manufacturing plant and/or the delivery of finished goods to various demand centres. Third-party logistics providers of this type typically operate in the context of long-term outsourcing arrangements on behalf of a manufacturer (Sink *et al.*, 1996; Razzaque and Sheng, 1998).

For both internal customers (manufacturers) and external customers (end-consumers), an LSP is concerned with achieving cost-effective satisfaction of customer requirements through buyer–supplier integration (Murthy *et al.*, 2004). For example, the goal of inbound logistics is to reduce the total costs by having the right materials at the right place at the right time (Holmstrom and Aavikko, 1994). An effective LSP thus enables the carrier to partner with a variety of service providers to manage the operation of a supply chain, which ultimately leads to a variety of benefits – including improved market performance, competitive advantage, higher levels of customer service, and improved cost-effectiveness between the shipper and the carrier (Cochran and Ramanujam, 2006).

The logistics manager must make judgments regarding his or her firm's performance relative to the competition. Such performance measurement facilitates identification of potentially successful management strategies and directs management attention to the appropriate revision of company goals and re-engineering of business processes (Bourne *et al.*, 2000). Accurate performance measurement is thus helpful in improving the LSP itself and the supply chain that it manages (Chan, 2003).

Historically, companies undertaking performance management have concentrated on financial indicators, but it is now widely recognised that non-financial (and even non-numerical) indicators can also provide valuable information on performance (Brewer and Speh, 2000; Ittner and Larker, 2003). However, such indicators are difficult to measure and compare. Moreover, a full set of indicators (both quantitative and qualitative) can entail a huge amount of data that requires considerable effort and cost to acquire and analyse. Another difficulty is that it is not uncommon for such a range of indicators to produce conflicting findings – leaving companies to deal with the dilemma of knowing that improving one measure might worsen another. Against this background, this study contends that the level of customer satisfaction is a useful indication of the required standard of overall performance of an LSP and its supply chain.

A customer-oriented approach to performance management is appropriate to an LPS because it usually provides process-based services (rather than function-based services) that are aimed at the integration of a whole process on behalf of the client (Carbone and Stone, 2005). If an LSP fails to meet the integrated quality, delivery and reliability requirements of the customer, additional costs are incurred by the LSP in correcting these deficiencies. These extra costs (direct, overhead and consequential) have an immediate impact on the LSP's available resources, and the consequent waste of human resources, equipment and time all have an adverse effect on the firm's competitive position.

The so-called "management by objectives" (MBO) Drucker (1954) has proved to be an effective approach to performance management. A total-cost approach using objective-based measures with a customer orientation is therefore the most appropriate approach to take in evaluating the performance of an LSP. Such a total-cost approach recognises that the purchase price is only a fraction of the cost associated with supply-chain management. Other costs exist that are not traditionally measured, but which are significant to long-term sourcing decisions and, ultimately, to bottom-line profitability (Krause *et al.*, 2001). However, such a total-cost approach requires the establishment of appropriate objective-based measurements. The best measures are customer-focused and goal-oriented (George and Weimerskirch, 1998).

3. A LSP performance-evaluation model

On the basis of the above discussion, this study proposes a customer-oriented, objective-based performance-evaluation model for an LSP. The model is presented in the context of an application of the proposed model in a case-study company in Taiwan.

3.1. Case company

The client firm utilising LSP services has manufactured switching power supply (SPS) units for the PC industry since 1970 in northern Taiwan. These SPS products are used as parts in the PC assembly lines of major manufacturers and suppliers – such as IBM, Sony, Siemens, and Hewlett-Packard, all of which have recently set up programs to streamline the supply process. In particular, the buyers of SPS units have introduced just-in-time (JIT) supply practices and have thus been requiring improved logistics performance from the manufacturing supplier. As a consequence, the manufacturer has been forced to require improved logistics performance from its own LSPs in terms of lead-time, reliability, and accuracy of shipments.

The LSPs of the manufacturer are paid for a range of specific value-added logistics services. These include: assembling/reassembly; repackaging/re-labelling; purchasing/ procurement; cross-docking; order processing; customer-specific label printing; fleet management; and warehousing. These services are purchased by the manufacturer for a certain price, which is negotiated on an annual basis. Because it operates in a very competitive scenario from a logistics point of view, the manufacturer needs to manage its customer service proactively if it is to retain its customers and gain new market shares.

Against this background, the approach proposed in this research project has been recognised by the senior management of the manufacturer as a useful strategy for the setting of objective-based targets for selected service factors and the development of an appropriate performance-evaluation program with a customer-satisfaction orientation (as shown in Table I). The items listed in Table I were to be used for assessment of services and products provided by the LSPs and in the evaluation of actions that management could undertake to improve the performance of the LSPs and thus enhance customer satisfaction.

3.2. Prevailing performance-assessment model

The prevailing approach of the firm at the time of the case study was a typical weighted-point LSP performance-rating system that is used in many industries. According to Feigenbaum (1985), a supplier performance rating can be obtained by assessing quality, price, and delivery. The Corporate Synergy Development Center (CSD), Taiwan, has extended this approach, based on the same concepts, and has suggested that the LSP's performance (Y) should be measured by:

$$Y = W_q Q + W_p P + W_d D, \quad W_q + W_p + W_d = 1 \tag{1}$$

Service factors	Strategic actions	Expected outcomes of customer satisfaction	Responsive organization	Character of indicator
Competitive cost	Just-in-time philosophy	Competitive price of total solution	Manufacturer	Price
Lead-time	Information technology		Retailers	Consequential loss of LSP's failing to meet organizational objectives (non-price)
Accuracy	Demand forecasting methods	Quality accepted	Customers	
Reliability	Customer relationship management	Delivery in time	End Users	
Fill rate		Correct parts/ quantity delivered		
Complaints management		Quick responsiveness for needed actions		

Table I.
Selected service factors vs considered strategic actions vs expected outcomes of customer satisfaction

where

$$\text{Q: score of quality} = 1 - \frac{\text{number of rejected lots}}{\text{number of received lots}} \tag{2}$$

W_q: weight of quality

$$\text{P: score of price} = P = 80\,\text{per cent} + \frac{(\text{Pt} - 1) - \text{Pt}}{\text{Pt} - 1} \times 100\,\text{per cent} \tag{3}$$

where Pt is the price in due period and Pt−1 the price in previous period.

W_p: weight of price

$$\text{D: score of delivery} = 1 - \frac{\text{number of delayed lots}}{\text{number of received lots}} \tag{4}$$

W_d: weight of delivery, W_p: 50 per cent, W_q: 25 per cent, and W_d: 25 per cent.

In practice, this popular LSP performance-rating model is unable to meet the requirements of a customer-oriented, objective-based assessment. In particular, it is unable to fulfil the desire to adopt a JIT approach to supply. The advantages of a new model become more obvious from an analysis of the concerns listed below:

(1) *Price*: The prevailing model considered neither the lowest price level of LSPs in the same industry nor the manufacturer target price (i.e. the maximum affordable price) for the desired services and products.

(2) *Customer orientation*: The model did not take account of level of satisfaction or the impact of quality and delivery issues for users of incoming materials on the production line and/or as end-customers. Quality and delivery issues that the model did not consider included the costs of rework, sorting, and shutdown that could occur on the production line if there were problems with the quality or delivery of delivered products/materials. Nor did the model consider complaints from customers regarding quality or delivery problems with respect to delivered products/materials.

(3) *Quality assessment*: The prevailing model treated all rejected lots in the same way, despite the fact that the proportion of defects within rejected lots are sometimes quite different.

(4) *Ship-to-stock*: The prevailing model did not allow for improved LSP efficiency when ship-to-stock programs are applied. (Equation (2) is not equally applicable to all LSPs.)

(5) *Objective-based*: The application of a single indicator to measure LSP performance with regard to tasks that have different characteristics (for instance, semiconductors compared with packing materials) will always provoke disagreement. It is more appropriate to set a target for each performance measurement.

3.3. Proposed customer-oriented objective-based model

In view of the above-mentioned concerns, this study proposed a new LSP performance-rating model for the case company. The aim was to establish an appropriate model utilising objective criteria of cost-effectiveness in accordance with a customer-satisfaction orientation. The proposed model built upon measures adopted to assess quality performance of suppliers as revealed in a survey by Pooler and Pooler (1997). These included: rejects; production stoppages due to poor quality; rework costs (in dollars or hours); scrap generated during material use; customer complaints; and acceptable materials (without deviations and/or warranty costs resulting from failures). The proposed model also took account of the fact that customer complaints represent valuable data that can assist an organisation in identifying the source of process errors (Breyfogle *et al.*, 2001).

3.3.1. Indicators of satisfaction with LSP. In all, six indicators were established at various stages in the process. The objective-based indicators (and the responsible departments) were determined as follows:

- initial stage: one indicator: "target price" (Tp); purchasing department responsibility;
- delivery receiving stage: two indicators: "lot reject rate" (Lr) and "lot delay rate" (Ld); responsibility of department that handles receiving and incoming inspection; and/or production line;
- production stage: one indicator: "line complaint" (Lc); responsibility of production line (internal customer);
- customer stage: one indicator: "customer complaint" (Cc); applicable to external customers and customer's customers; and
- overall: one indicator: "complaint service" (Cs); responsibility of department that handles receiving and incoming inspection; and/or production line.

3.3.2. Target values of LSP performance. At year end, the manufacturer assesses the performance of each LSP with respect to materials supplied and sets a suitable performance target value for each indicator (Ld, Lr, and so on). Examples from the case company are provided in Table II (metal material LSP in 2006) and Table III (semiconductor LSP in 2006).

3.3.3. LSP performance measurement. Our study establishes a new model through the integration of six indicators: Tp, Ld, Lr, Lc, Cc, and Cs, with appropriate weights r_1, r_2, r_3, r_4, r_5, and r_6, respectively. "Performance, P" was obtained by matching "Achievement Level, AL", a range of percentages from "actual value" and "target value" comparisons for each indicator. This system is explained precisely based on the definitions in this study.

No.	Indicator	Value (2005)[a]	Target value (2006)	Remark
1	Tp	US$17.0	US$16.1[b]	Average of the 4th Quarter 2005[a]
2	Lr	2.0%	1.0%	
3	Ld	1.0%	0.5%	
4	Lc	1.8 times	0	Yearly average
5	Cc	1.5 times	0	
6	Cs	0.65	1	

Notes: [a;b]5 per cent reduced

Table II.
Target value: metal material LSP, 2006

Actual Tp → compare with target Tp → get an AL → obtain a "PTp, Tp Performance value" through matching.

The Lr, Ld, Lc, Cc, and Cs (PLr, PLd, PLc, Cc, and PCs) performance is measured in the same way.

1. *Value-setting for indicators*. Formula-example 1 expresses the value-setting details of the new approach.

Formula-example 1: PTp – Performance of Tp

Formula: PTp = achievement level of target Tp, ALn

0.50 = AL1: Tp lower than target, percentage is higher than 60 per cent

0.80 = AL2: Tp lower than target 41-60 per cent

0.90 = AL3: Tp lower than target 21-40 per cent

0.95 = AL4: Tp lower than target 6-20 per cent

1.00 = AL5: Tp equivalent to target ± 5 per cent

1.05 = AL6: Tp higher than target 6-20 per cent

1.10 = AL7: Tp higher than target 21-40 per cent

1.20 = AL8: Tp higher than target 41-60 per cent

1.50 = AL9: Tp higher than target, percentage is higher than 60 per cent

Or we may have many kinds of value-setting either in levels" number of achievement or in degree range of actual output vs. target depending on the requirements of organisation. It will be more effective, sensitive, and flexible in required performance measurement. Two additional examples of ratio-setting are shown below.

Formula-example 2: PTp – Performance of Tp:

Formula: PTp = achievement level of target Tp, ALn

0.20 = AL1: Tp lower than target, percentage is higher than 80 per cent

0.40 = AL2: Tp lower than target 61-80 per cent

0.60 = AL3: Tp lower than target 41-60 per cent

0.80 = AL4: Tp lower than target 21-40 per cent

1.00 = AL5: Tp equivalent to target ± 20 per cent

1.20 = AL6: Tp higher than target 21-40 per cent

No.	Indicator	[a]Value (2005)	Target value (2006)	Remark
1	Tp	US$6.8	US$6.5[b]	Average of the 4th Quarter 2005[a]
2	Lr	0.1%	0.05%	
3	Ld	0.4%	0.2%	
4	Lc	0.3 times	0	Yearly average
5	Cc	0.2 times	0	
6	Cs	0.75	1	

Notes: [a;b]5 per cent reduced

Table III.
Target value: semiconductor LSP, 2006

1.40 = AL7: Tp higher than target 41-60 per cent

1.60 = AL8: Tp higher than target 61-80 per cent

1.80 = AL9: Tp higher than target, percentage is higher than 80 per cent

Formula-example 3: PTp – Performance of Tp:

Formula: PTp = achievement level of target Tp, ALn

0.50 = AL1: Tp lower than target, percentage is higher than 80 per cent

0.80 = AL2: Tp lower than target 31-80 per cent

1.00 = AL3: Tp equivalent to target ± 30 per cent

1.20 = AL4: Tp higher than target 31-80 per cent

1.50 = AL5: Tp higher than target, percentage is higher than 80 per cent

Similarly, the flexibility of ratio-setting can be applied for at least some of the other indicators, Ld, Lr, Lc, Cc, and Cs,. It is necessary to maintain consistency and continuity of performance measurements. The weights r_1, r_2, r_3, r_4, r_5, and r_6, can be set by constructing a scale – rating these performance indicators/objectives in terms of their relative importance. It is strongly recommended that decision-makers approximate the importance of each indicator using AHP and pairwise comparisons (Saaty, 1980).

The details of this approach are expressed by:

(1) *PTp – Performance of Tp:*

Operating:

- the calculation is based on the purchasing results of product and service;
- on a monthly basis; and
- the performance depends on the target Tp achievement level.

Formula: PTp = achievement level of target Tp, AL_n

1.00 = AL1: Tp lower than target, percentage is higher than 60 per cent

0.95 = AL2: Tp lower than target 41-60 per cent.

:

:

0.80 = AL5: Tp equivalent to target ± 5 per cent

:

:

0.65 = AL8: Tp higher than target 41-60 per cent

0.60 = AL9: Tp higher than target, percentage is higher than 60 per cent

(2) *PCs – Performance of PCs:*

Operating:

- on a monthly basis;
- the target Cs is 0;

- complaint service is defined as the efficiency and effectiveness in handling the manufacturer's complaint (the complaint is made by the manufacturer when Tp, Ld, Lr, Lc or Cc does not reach the yearly target.). Each case is judged by the IQA department; and
- the performance depends on the efficiency & effectiveness of the LSP's corrective actions.

Formula:

PCs = 1, when Cs = 0

$$= \frac{A's \times 4 + B's \times 3 + C's \times 2 + D's \times 1}{\text{number of corrective action request} \times 4}$$

A's: LSP's response/action is excellent × times

Return handling is very quick, within one week. The actions taken with detail analysis are effective, significant improvement in the next delivery.

B's: LSP's response/action is acceptable × times

Having significant improving results can be observed in the next delivery, but the response is delayed, longer than one week.

C's: LSP's response/action is poor × times

Only return complaint sheet, no improvement action or actions taken without effectiveness shown in the next delivery.

D's: LSP's response/action is not acceptable × times

No response.

(3) *PLc – Lc Performance:*

Operating:

- based on the number of cases verified by IQA and the production line;
- the target Lc is 0; and
- on a monthly basis.

Formula:

$PLc = 1.0$, when $Lc_1 + Lc_2 = 0$

$PLc = 0.5$, when $Lc_1 + Lc_2 = 1$

$PLc = 0.0$, when $Lc_1 + Lc_2 > 1$

Lc_1: Line complaint due to released material line reject rate higher than 1 per cent and rework, sorting occurring in production × times

Lc_2: Line complaint due to production shutdown caused by mixing or incorrect released material × times.

(4) *PLr – Performance of Lr:*

Operating:

- based on the lot reject rate verified by IQA;
- on a monthly basis; and
- the performance depends on the Lr target achievement level.

Formula:

1.0 = AL1: Lr lower than target, percentage is higher than 50 per cent

0.8 = AL2: Lr lower than target 21-50 per cent

0.6 = AL3: Lr equivalent to target ± 20 per cent

0.4 = AL4: Lr higher than target 21-50 per cent

0.2 = AL5: Lr higher than target, percentage is higher than 50 per cent

(5) *PLd – Performance of Ld:*

Operating:

- based on the lot delayed rate verified by receiving department;
- on a monthly basis; and
- the performance depends on the Ld target achievement level.

Formula:

1.0 = AL1: Lr lower than target, percentage is higher than 50 per cent

0.8 = AL2: Lr lower than target 21-50 per cent

0.6 = AL3: Lr equivalent to target ±20 per cent

0.4 = AL4: Lr higher than target 21-50 per cent

0.2 = AL5: Lr higher than target, percentage is higher than 50 per cent

(6) *PCc – Performance of Cc:*

Operating:

- based on the number of issues verified by IQA, Engineering, the production line and Outgoing Quality Assurance (OQA) department.
- the target Cc is 0; and
- on a monthly basis

Formula:

PCc = 1, when Cc = 0

PCc = 0, when Cc $\geq$ 1

Cc: Customer complaint is caused by released material quality or reliability problem × times.

2. LSP performance measurement formula

- If a LSP supplies just one group of parts, the LSP performance value (P_L) will be the same as the supplier performance value (Ps). This value is given by

$$P_L = Ps = 100 \times (r_1 PTp + r_2 PLd + r_3 PLr + r_4 PLc + r_5 PCc + r_6 PCs) \quad (5)$$

where

$$r_1 + r_2 + r_3 + r_4 + r_5 + r_6 = 1, \quad r_i \geq 0, 1 \leq i \leq 6$$

- If a LSP supplies several kinds of parts (more than one group), the PL is obtained using

$$PL = \frac{Pl_1 + Pl_2 + \cdots + Pl_n}{n} \tag{6}$$

where $n > 1$.

- The parameters in this formula are applied flexibly to cover all kinds of LSP with different characteristics:

For instance:

If a LSP has been adopted for the ship-to-stock program and is not suitable for Lr, the parameter weights can be

$$r_1 + r_2 + r_4 + r_5 + r_6 = 1$$

4. Results comparison

An example is presented to demonstrate how the proposed model, Formula (5), could be applied in a LSP performance rating. It is compared with the popular model, Formula (1). The basic manufacturer purchased subassembly data from 3 LSPs (LSP_1, LSP_2, LSP_3) with different target price is given in Table IV. The results from the popular model, Formula (1), and the proposed model, Formula (5), are shown in Tables V and VI, respectively. Significant accurate and effective performance rating results for different LSP achievement levels were obtained applying the proposed model, Formula (5).

5. Conclusions

The proposed LSP performance-rating model can be applied by a variety of manufacturers to assess all kinds of LSPs in various industries. The proposed

Indicator	Weight	Target	Basic data	LSP_1 January	LSP_1 February	LSP_2 January	LSP_2 February	LSP_3 January	LSP_3 February
PTp	0.2	Lower than Tp	Actual price	17.2	17.0	8.2	8.3	11.1	11.0
			Target price	16.1	16.1	9.0	9.0	11.0	11.0
PLd	0.1	0.5%	Delayed lot	0	1	0	0	0	0
			Received lot	25	22	22	23	26	24
PLr	0.1	1.0%	Rejected lot	0	0	0	0	1	0
			Received lot	25	22	22	23	26	24
PCs	0.2	0	A's	0	0	0	0	1	0
			B's	0	0	1	0	0	0
			C's	0	1	0	0	0	0
			D's	0	0	0	0	0	0
PLc	0.2	0	LC_1	0	0	0	0	0	0
		0	LC_2	0	0	1	0	0	0
PCc	0.2	0	Cc	0	0	0	1	1	0

Notes: Group: metal material; time: January-February, 2006

Table IV. The basic data on manufacturer's purchased material from three LSPs (LSP_1, LSP_2, LSP_3)

model can assist manufacturers in selecting the best LSP and integrating LSP capabilities to develop an appropriate quality-and-profit improvement program using objective-based, customer-specific requirements. The proposed model is complete, flexible, and effective.

The model can be said to be complete because it integrates six performance indicators and covers four supply-chain stages (from vendor to LSP to manufacturer to customer). The main activities of purchasing and integrated quality assessment (IQA) are horizontally involved in this system. The system extends the customer-satisfaction concept vertically – from purchasing and IQA to the user and customer.

The model is flexible because it provides six flexible weights to combine performance parameters in a linear fashion that enables manufacturers to formulate the most suitable measurement equation for various kinds of LSPs in different industries. To ensure accuracy, different weight combinations (r_1, r_2, r_3, r_4, r_5, and r_6) can be set in the system.

Finally, the model presented in this study is effective because it provides an effective method for assessing performance improvement with measurable, JIT criteria. An LSP's grading can be developed on the basis of the LSP's performance rating. This assists manufacturers in adopting suitable strategic actions to improve an LSP's performance.

Table V. The basic data on manufacturer's purchased material from three LSPs (LSP_1, LSP_2, LSP_3) using Formula (5)

Indicator	Weight	Target	Measure	LSP_1 January	LSP_1 February	LSP_2 January	LSP_2 February	LSP_3 January	LSP_3 February
PTp	0.2	Down 5%	ALn	0.75	0.75	0.85	0.85	0.8	0.8
PLd	0.1	0.5%	ALn	1.0	0.2	1.0	1.0	1.0	1.0
PLr	0.1	1.0%	ALn	1.0	1.0	1.0	1.0	0.2	1.0
PCs	0.2	0	Time and quality	1.0	0.5	0.75	1.0	1.0	1.0
PLc	0.2	0	Time	1.0	1.0	0.5	1.0	1.0	1.0
PCc	0.2	0	Time	1.0	1.0	1.0	0.0	0.0	1.0
Total (%)				95	77	82	77	68	96

Notes: Group: sub-assembly; time: January-February, 2006

Table VI. The basic data on manufacturer's purchased material from three LSPs (LSP_1, LSP_2, LSP_3) using Formula (1)

Indicator	Weight	Target	Measure	LSP_1 January	LSP_1 February	LSP_2 January	LSP_2 February	LSP_3 January	LSP_3 February
P	0.5	–	Formula (3)	^{a}0.8	0.812	^{a}0.8	0.788	^{a}0.8	0.809
Q	0.25	–	Formula (2)	1.00	0.955	1.0	1.0	1.0	1.0
D	0.25	–	Formula (4)	1.0	1.0	1.0	1.0	0.962	1.0
Total (%)				90.0	89.5	90.0	89.4	89.1	90.5

Notes: Group: metal material; time: January-February, 2006; $^aP_{t-1}=P_t$ is assumed for calculations

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