Available online at www.sciencedirect.com
ScienceDirect
Journal of Purchasing & Supply Management 13 (2007) 152–165
JOURNAL OF PURCHASING AND SUPPLY MANAGEMENT
www.elsevier.com/locate/pursup

Notes and Debates

Linear performance pricing: A collaborative tool for focused supply cost reduction

W. Rocky Newman[a,*], Timothy C. Krehbiel[b,1]

[a]Department of Management, Farmer School of Business, Miami University, Oxford, OH 45056, USA
[b]Department of Decision Sciences and MIS, Farmer School of Business, Miami University, Oxford, OH 45056, USA

Received 8 August 2006; received in revised form 11 June 2007; accepted 11 June 2007

Abstract

Supplier networks and the buyer/supplier relationships that comprise them are becoming increasingly important to effective supply chain management. Trust, collaboration, and efficient sharing of information are critical for true win/win relationships to surface in an environment where there is constant pressure to reduce costs and still maintain reasonable profitability. The use of across-the-board cost reduction demands and simple market clout may not always be the most effective approach in the long run. This paper describes linear performance pricing (LPP), a tool developed for a major automobile OEM in an attempt to effectively and efficiently provide more focused supply cost reductions. LPP is a data-driven methodology relying on a series of regression analyses that McKinsey and Company [2006. Automotive and assembly glossary. ⟨http://autoassembly.mckinsey.com/html/resources/glossary/1.asp⟩ (accessed 15.01.06)] describes as a "measurement tool that establishes a relationship between the value provided by a given part (performance) and its price." We maintain that LPP facilitates a collaborative effort on the part of both the buyer and supplier and has the potential for leveraging the increased visibility of the buyer within the supplier network with respect to tier one or tier two suppliers. It helps by focusing cost reduction efforts of the tier one suppliers and provides lateral market visibility they may not have otherwise. Although widely used throughout the automotive industry in the US and Europe, little discussion of LPP is found in the literature. To promote a better understanding of LPP, we present a detailed example and discuss the managerial implications of the approach.

Keywords: Buyer/supplier relations; Cost reduction; Regression analysis

1. Introduction

A broad base of literature defines a business relationship as a process where two firms or other types of organizations form strong and extensive social, economic, service, and technical ties over time with the intent of lowering total costs and or increasing value, thereby achieving mutual benefit (Ritter et al., 2004). Managing the network of complex relationships between supply chain entities is a growing area of concern for most companies (Ford et al., 2002). As the challenges associated with developing the competencies necessary to support cross functional thinking within an organization are extrapolated outward toward those necessary to support cross organizational relationships, associated tools must also be developed and modified.

As advances in information technology support the development of richer and more sophisticated relationships between supply chain entities (Quinn, 2004), the distinction between a firm's core and non-core activities can better be made. There is less reason to keep non-core activities in house only for reasons of control and a firm's true competitive advantages and capabilities (i.e., their core activities) become obvious (Fine, 2000). Core activities can be better exploited and non-core activities can be more easily outsourced. As a result, many industries such as the automotive, consumer electronics, and mass merchandiser retail, to name a few, are outsourcing a larger percentage of their revenue than ever, and as they become more focused

*Corresponding author. Tel.: +1 513 529 4219; fax: +1 513 529 2342.
E-mail addresses: Newmanw@muohio.edu (W.R. Newman), Krehbitc@muohio.edu (T.C. Krehbiel).
[1]Tel.: +1 513 529 4837; fax: +1 513 529 9689.

1478-4092/$ - see front matter © 2007 Elsevier Ltd. All rights reserved.
doi:10.1016/j.pursup.2007.06.004

on the core activities by which they continue to add value, the importance of simultaneously managing their supply chain networks is increasing. As more of the value adding to their product takes place outside the firm, more of the potential for competitive success depends on the supply chain.

Increased percentages of revenue that are outsourced can also increase the leverage that supply base cost reductions have on the overall performance of a firm. Consider a typical firm spending 70% of revenue on purchased material from its suppliers. Assume the firm's earnings before taxes (EBT) are 3% ($3 per $100 in revenue, or 10% of the revenue not passed directly on to its suppliers). While the price/earnings (P/E) ratio is most commonly associated with the price and earnings per share of common stock, it can also be used in terms of revenue. If that same firm has a P/E ratio of 25, then the market capitalization of the firm would be $75 per $100 in revenue. Should that firm take 2% out of its "spend" ($70 per $100), it would generate another $1.40 directly to earnings. An enhanced EBT of 4.4% (i.e., $4.40 per $100 in revenue) would mean an improved market capitalization of $110 per $100 in revenue, a 46% increase. Table 1 describes the same analysis as the ratio of spend increases from 30% of a firm's revenue (typical of labor intensive high value adding industries) to as much as 95% (typical of many fast moving and lean retail chains). The leverage of that same 2% decrease in spend is greatly enhanced as the proportion of spend increases.

Supplier performance in terms of cost is clearly a major concern in supplier relationship management. Fig. 1 illustrates a commonly held strategic taxonomy (Newman and Krehbiel, 2006) where suppliers are grouped by cost-based metrics and quality-based metrics. For our purposes, given the significance of high quality as a prerequisite to doing business, we assume all suppliers are in the top two quadrants. Arguably within the scope of our analysis, firms with tier one suppliers in the upper-left quadrant (high on quality but not high on cost effectiveness) need to find ways to help those suppliers improve their cost effectiveness and move toward the upper-right hand quadrant (high on both quality and cost effectiveness). This taxonomy allows the buyer to focus on managing the exceptional cost relationships within their supplier network. In fact, many times the buying firm is in a position to help the supplier make that transition by helping them understand the issues that drive cost across other suppliers to the buying firm.

Newman and Krehbiel (2006) also discussed the complexity of lowering supplier costs in complicated supply chain networks as illustrated in Fig. 2. This figure suggests that when considering the potential for cost reduction, the total cost of ownership needs to be considered. Given that much of that cost is imbedded in the value purchased from tier one suppliers (who in turn purchase from tier two suppliers, etc.), the most potential for improvement may not always exist within the value adding process of the OEM but at the tier one or tier two level. Consider the firm spending 80–90% of its revenue with its tier one suppliers. In many cases, tier one suppliers may be in a situation similar to the OEM in that they are sourcing an equally high percentage of their revenue from tier two suppliers. Fig. 3 hypothetically examines the spend at each tier. It is only at the second tier where the proportion of value added to spending increases. Like the OEM, this may limit the potential for cost reductions at the tier one level and significant potential for supply cost reduction may be at the second tier or even lower relative to the OEM.

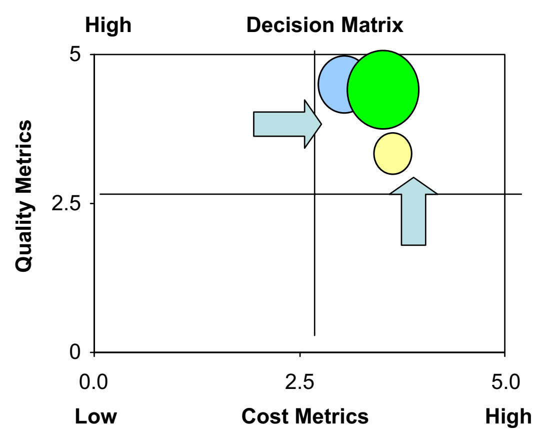

Fig. 1. Sourcing decision matrix.

Table 1
Motivation to reduce cost of purchased material by 2%

Purchased material as a percent of revenue	Incremental value added as a percent of revenue	Earnings as a percent of revenue[a]	Earnings[b]	Stock price[b]	Savings after −2%[b]	Improved earnings[b]	New stock price[b]	Change in stock price (%)[b]
90.00	10.00	1.00	$1.00	$25	$1.80	$2.80	$70	180
80.00	20.00	2.00	$2.00	$50	$1.60	$3.60	$90	80
70.00	30.00	3.00	$3.00	$75	$1.40	$4.40	$110	47
60.00	40.00	4.00	$4.00	$100	$1.20	$5.20	$130	30
50.00	50.00	5.00	$5.00	$125	$1.00	$6.00	$150	20
40.00	60.00	6.00	$6.00	$150	$0.80	$6.80	$170	13
30.00	70.00	7.00	$7.00	$175	$0.60	$7.60	$190	8.6

[a]Assumes earnings at 10% of incremental value added.
[b]Per $100 in revenue.

Consistent with the extended supply network perspective described above (rather than individual dyads), LPP addresses price and performance across the supply base. It provides the ability to focus on individual relationships with specific suppliers in an attempt to improve two of the more critical SCM processes defined by Lambert (2004), specifically supplier relationship management and product design/development.

As a firm outsources a greater percentage of their spend, the associated increased importance of controlling supplier costs requires looking beyond across-the-board price discounts. For many firms with a high level of spend (e.g., automotive OEMs), the pressure to reduce costs can be very high. With very little room for improvement, that pressure is often transferred to their supply base. Even then, tier one suppliers may outsource an equally large percentage of their revenue and be forced to pass the pressure on to tier two suppliers where a large value added proportion of revenue may provide more potential for cost reduction. But as Fig. 1 suggests, some suppliers already perform better than others. Across-the-board pressure fails to recognize the difference between supplier cost performances. Tools need to be developed that help identify the difference in a proactive and collaborative fashion in order to facilitate more focused improvement wherever possible.

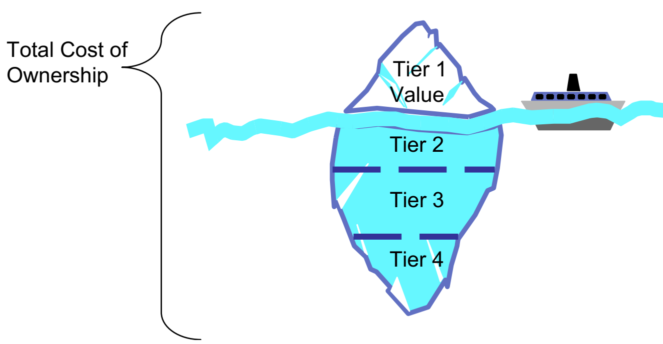

Fig. 2. Where is the potential for cost reduction?

This paper examines linear performance pricing (LPP), an approach taken by a major international auto manufacturer to effectively manage supply base cost reductions. LPP uses regression analysis to competitively link tier one purchased component content and performance attributes to their cost drivers and subsequent tier two supplier component cost. The OEM has been using LPP models for approximately 7 years and currently has over 200 models in place. The models are used for over 50,000 different parts from more than 900 different suppliers located around the world. In total, about 85% percent of their direct production material purchases are affected in some way by LPP models, and they expect to see a moderate increase in their use over the next few years. Benefits gained by using LPP include transparency of cost drivers; internal/external resource optimization, design optimization leading to lower cost of goods sold, and improved supplier relations through data-based discussions. In addressing the collaborative nature of LPP, the OEM's supply network has benefited through the increased transparency of cost drivers across tiers, better communication between tiers, and more focused negotiations with the OEM

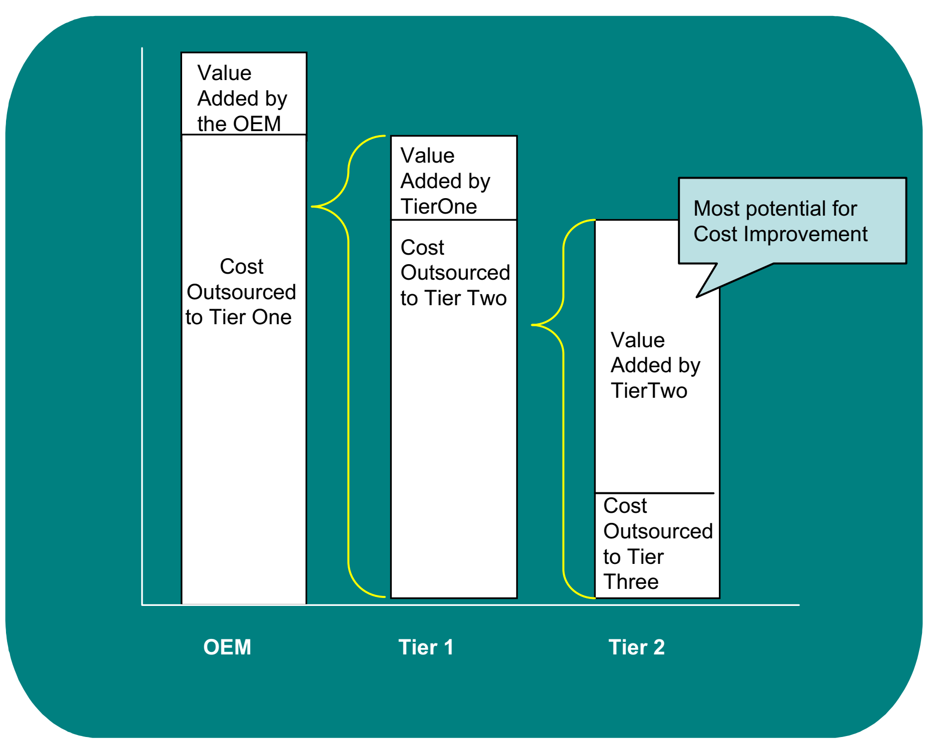

Fig. 3. Breakout of potential for cost reduction?

through the data-based discussions within customer and supplier organizations.

2. Existing literature

Ritter et al. (2004) and a variety of authors define a business relationship in terms of a dyadic process between two firms. Anderson et al. (1994) argue that an extended reality for most businesses is the need to manage a network of suppliers comprised of a number of these sorts of dyadic relationships. Brito and Roseira (2003) argue that better management of these supplier networks influences the buying company's strategy and performance.

Ford and MacDowell (1999) suggest that attempts to manage relationships with suppliers within a firm's supply chain may not have the same impact on all relationships. Other scholars (e.g., Brito and Roseira, 2003; Leek et al., 2001) further suggest that the effective management of suppliers should not be reduced to managing a collection of individual dyadic relationships. Rather, the interactions between those dyadic relationships (i.e., the supplier network) should be the focus of attention. They suggest a gap in the research where networks with a large number of participants are concerned.

Lambert (2004) identifies the basic processes of supply chain management including those of supplier relationship management and product design and development. Evans et al. (1995) suggest that the radical evaluation of these processes is necessary. Zsidisin and Smith (2005) examine supplier networks in terms of supply risk and early supplier involvement. The potential contribution of supplier networks to product design is identified in Yang and Burns (2003), Rungtusanatham and Forza (2005), Forza et al. (2005) and Petersen et al. (2005). Damodaran and Wilhelm (2005) as well as Meixell and Wuz (2005) examine the role of suppliers in product design from an analytical perspective.

While significant literature exists to frame and define the complexities of managing the supplier network, more work is needed. A recent survey by Computer Sciences Corporation (Institution of Electrical Engineers, 2004/2005) suggests that while technology exists to support improvement, actual strategy, buyer/supplier relationships, and process improvements are lagging. Moreover, although LPP is used extensively in some arenas, little has been written on the subject. McKinsey and Company (2003) highlights the potential cost savings advantages of LPP, and concerns governing the use (or misuse) of LPP can be found in Wernle (2004) and Sherefkin (2003). None of the articles, however, present a detailed example of how the method works or the method's managerial implications. As such, we feel a discussion of LPP's use in practice may begin to fill some important gaps in the literature.

3. Linear performance pricing

LPP can be used to identify areas for competitive understanding and improvement in the purchasing relationship between the OEM and tier one and tier two suppliers. Using the OEM's vantage point in the supply chain network, supply cost reduction efforts can be more focused on situations where current costs are neither supported by the market place or demand for component performance attributes. LPP allows firms to better negotiate initial costs for components of new products as well as helps focus efforts to negotiate reduced costs for currently sourced or newly redesigned components. Moreover, the efforts and discussions throughout the supplier network are data-driven and focus on design optimization as well as competitive positioning.

Considering the analysis demonstrated in Table 1, this approach is based on an OEM that spends almost 80% of revenue on direct material in order to mass produce a variety of automobile product lines, many of which share common basic designs and many similar components. Many components (e.g., steering wheels, radiators, wheels, engines, transmissions) vary in terms of content, performance, and most of all, cost. Fig. 4 illustrates the general LPP model. For example, consider the hypothetical case of a steering wheel that may be sourced in a variety of models

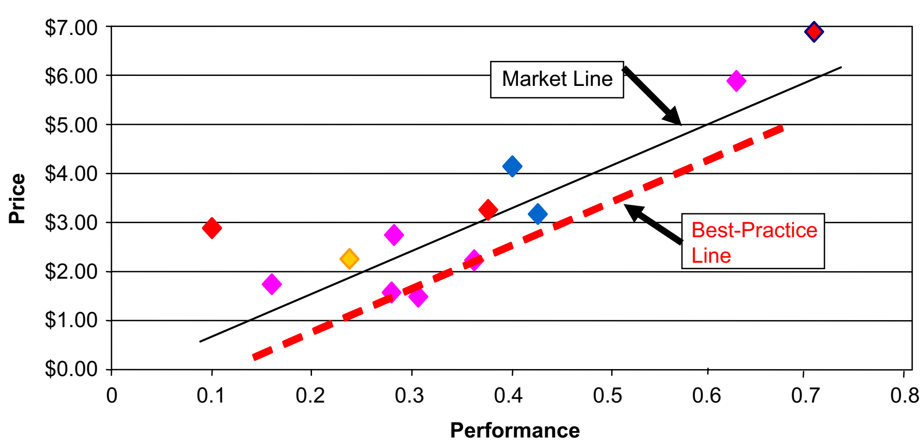

Fig. 4. Linear performance pricing.

from suppliers (some of which may even be sole suppliers for a given model). When plotting the price of each model against a performance index (i.e., what they feel it should cost based upon drivers like diameter, strength, and complexity), a linear relationship becomes apparent with some prices above the line and some below the line. The solid line in Fig. 4 is referred to as the *market line*. By isolating those furthest below the line, a second line, called the *best-practice line*, can be estimated to demonstrate the potential for cost reduction. The best-practice line, the dashed line in Fig. 4, is typically derived by using the 20–30% of the parts furthest below the market line. In terms of managing supplier relations and new product development, product designers and purchasing managers can use this type of analysis to support collaborative advance product design and quality planning processes. The ability to place a supplier's relative capability into a broader context can help identify areas where more business should be directed and where improvements may be needed to support current business levels. As OEMs work with tier one suppliers, their collective analysis can then be extended to tier two suppliers and beyond.

When an OEM looks to its supply base for cost reductions, Fig. 4 makes it clear some suppliers are already supplying components at more competitive cost/performance levels than others. Thus, across-the-board demand for concessions would only penalize those suppliers already operating at below-market or best-practice costs. Secondly, as suggested earlier by Figs. 2 and 3, simply pressuring the first tier suppliers whose components are above the best-practice line for greater cost concessions may not be effective as those suppliers may themselves outsource a large percentage of their components and thereby limit their potential for truly efficient cost reductions. The LPP model, however, could help those tier one suppliers (especially those who source a large percentage of their sell) identify tier two suppliers where the most effective cost reductions are possible. And, as illustrated earlier in Table 1, the leveraging afforded by cost reductions in these situations leads to significant improvement in the financial performance of the OEMs.

Buying many similar or related components from a variety of tier one suppliers places the OEM in a position to compare component cost to the content index or performance attributes (size, capacity, features, strength, horsepower, etc.) most relevant to their sourcing needs. By working with tier one vendors across multiple models of each component type (e.g., wheel and axle assemblies for all the different cars that they make) they can identify many of the common cost drivers those tier one suppliers face in their respective environments. The regression-based approach discussed in this paper, LPP, allows the OEM to identify tier one prices that are not in line with other suppliers of the same type component in order to either explain those differences in terms of value added to the OEM (which in many cases may explain and justify costs above the market average), or to help those tier one vendors identify cost improvement opportunities within their firms or, more commonly, within tier two suppliers. In comparison to across-the-board demands for price reductions that the OEM might make based upon their own volume and market-based clout, LPP supports a more focused approach to aid price negotiations. LPP targets suppliers whose prices and underlying cost structures are not in line with the general marketplace yet uses OEM's vantage point within the marketplace to put tier one prices in the broader context of content or performance attributes inherent in their offerings to the tier one.

3.1. An example

Consider a hypothetical family of subassemblies representative of those typically sourced by an OEM using LPP. The subassemblies, suppliers, costs, and volumes are all obviously fictional but serve as an effective illustration of the approach. Assume that a set of somewhat similar modules each comprised of four wheels, a front axle, and a rear axle are purchased from various tier one suppliers (see Fig. 5). The tier one suppliers in turn source those subcomponents from a potentially wider set of tier two suppliers. The modules are assembled by the tier one suppliers and shipped to the OEM. Twenty models are sourced from a total of seven tier one suppliers. Table 2 lists the model, actual price, and weekly volume for each of the 20 models.

To perform LPP, we need to construct a regression model similar to the model illustrated in Fig. 4. The model will predict the price of the wheel & axle modules based on a performance index. Performance can be measured by value, cost, content, quality, etc. A performance index for modules such as these is determined by what the individual components of the modules should cost, plus a value added component. (In the managerial implications section we address the issue of how to measure performance.)

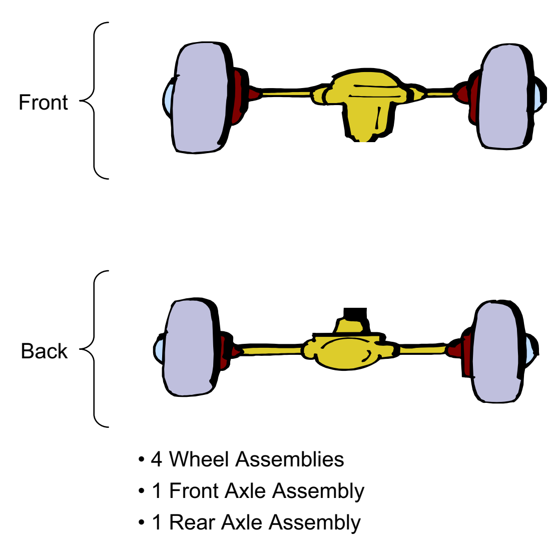

Fig. 5. Wheel & axle modules.

We begin by calculating what the wheels should cost. These estimates of value are often suitably named "should costs." In Table 3, we list the actual price of each wheel (4 per module) along with the three suggested cost drivers incurred by the tier two suppliers; weight, thickness, and volume. Note that volume is assumed to have a negative coefficient suggesting an economy of scale in sourcing that subcomponent. These cost drivers are identified by discussions with both tier one and tier two suppliers. A regression using price as the dependent variable and weight, thickness and volume as independent variables was performed and the results in Table 4 suggest a good fit. The prediction equation is then used to predict the should cost for each wheel. The difference between the actual price and the should cost helps to identify those wheels priced above and below the market (see the last column in Table 3).

Table 2
Wheel & axle module

Model	Actual price	Volume
Acme A	$131.46	400
Acme B	$130.10	750
Acme C	$162.15	125
Baker D	$105.01	25
Baker E	$120.67	25
Baker F	$137.88	15
Baker G	$135.00	15
Baker H	$151.01	25
Baker I	$157.15	20
MMS J	$110.52	125
MMS K	$128.81	100
MMS L	$143.11	125
Northern M	$105.87	500
Northern N	$121.00	375
Northern O	$121.83	300
ConFab P	$110.50	1250
Western Q	$165.17	30
Western R	$180.11	25
Western S	$181.11	40
Western T	$184.53	40

Tables 5 and 6 contain the results from a similar analysis for the front axle assembly. Here the should costs are predicted from the cost drivers length, thickness, and volume. The results for the analysis of the rear axle assembly are found in Tables 7 and 8. As in the case of the wheels, deviations above and below the market price are identifiable for both rear and front axles.

Table 9 combines the should costs of all the subcomponents along with an estimated allowance for value added by the tier one supplier into an "expected price." This expected price now becomes the performance index for the LPP model (i.e., the horizontal axis in Fig. 4). Note that the value add component would in reality be a negotiated or market driven value representing a reasonable margin from which the tier one must cover all its other costs and still make a reasonable profit. We have hypothetically estimated it as a function of the supplier's estimated subcomponent should cost and volume (again implying an economy of scale).

After calculating the expected price in Table 9, a regression analysis is performed using expected price as the independent variable and actual price as the dependent variable. The prediction line (see Table 10) is called the market line (see Fig. 6). The 25% of the wheel & axle modules priced furthest below the market line are then labeled as best practice. These five subassemblies identified in Table 11 include Baker H, MMS J, Northern M, Northern O, and ConFab P. A regression analysis for these five items (see Table 12) determines the best-practice line

Table 3
What wheels should cost

Model	Price	Weight (lbs)	Thickness (cm)	Volume	Should cost	Difference
Acme A	$14.00	16.00	1.45	1600	$10.47	*$3.53*
Acme B	$14.23	17.00	2.00	3000	$10.79	*$3.44*
Acme C	$18.45	18.00	2.55	500	$14.42	*$4.03*
Baker D	$10.57	15.50	1.00	100	$10.66	−$0.09
Baker E	$12.01	16.75	1.50	100	$12.19	−$0.18
Baker F	$13.60	18.00	2.50	60	$14.70	−$1.10
Baker G	$14.32	19.25	2.75	60	$15.75	−$1.44
Baker H	$16.20	20.50	3.00	100	$16.77	−$0.57
Baker I	$15.09	21.75	1.75	80	$15.00	$0.08
MMS J	$9.89	12.00	2.00	500	$10.59	−$0.70
MMS K	$11.00	13.00	2.00	400	$11.14	−$0.14
MMS L	$10.95	14.00	2.00	500	$11.52	−$0.57
Northern M	$8.27	12.75	1.75	2000	$9.19	−$0.92
Northern N	$9.22	15.00	1.75	1500	$10.66	−$1.44
Northern O	$9.68	16.00	1.75	1200	$11.38	−$1.70
ConFab P	$8.72	22.00	1.75	5000	$10.94	−$2.22
Western Q	$17.88	31.00	1.00	120	$17.85	$0.03
Western R	$19.35	34.00	1.50	100	$20.21	−$0.86
Western S	$22.84	37.00	1.75	160	$22.03	$0.81
Western T	$22.50	37.00	2.00	160	$22.50	*$0.00*

Table 4
Regression analysis for wheels

Predictor	Coefficient	Standard error	*t*-Statistics	*P*-value
Constant	1.646	2.290	0.719	0.483
Weight	0.465	0.057	8.202	0.000
Thickness	1.895	0.861	2.199	0.043
Volume	−0.0009	0.00036	−2.399	0.029

$S = 1.890$; $R^2 = 84.7\%$; adjusted $R^2 = 81.8\%$
Analysis of variance

Source	d.f.	SS	MS	*F*-statistics	*P*-value
Regression	3	316.2	105.4	29.50	0.000
Error	16	57.1	3.57		
Total	19	373.3			

Wheel should cost = 1.646 + 0.465(weight) + 1.895(thickness)−0.0009(volume).

Table 5
What front axle assemblies should cost

Model	Price	Length (cm)	Thickness (mm)	Volume	Should cost	Difference
Acme A	$29.60	12.00	12.00	400	$29.01	$0.59
Acme B	$29.10	12.00	13.00	750	$29.40	−$0.30
Acme C	$35.25	14.00	14.00	125	$34.86	$0.39
Baker D	$29.05	14.00	8.00	25	$28.32	$0.73
Baker E	$32.45	14.00	12.00	25	$32.82	−$0.37
Baker F	$34.57	14.00	14.00	15	$35.10	−$0.53
Baker G	$32.57	15.00	10.00	15	$32.11	$0.46
Baker H	$37.05	15.00	15.00	25	$37.71	−$0.66
Baker I	$41.16	15.00	19.00	20	$42.23	−$1.07
MMS J	$31.05	12.00	13.00	125	$30.71	$0.34
MMS K	$35.20	14.00	14.00	100	$34.92	$0.28
MMS L	*$46.15*	*15.00*	*20.00*	*125*	*$43.13*	$3.02
Northern M	$33.65	15.50	11.00	500	$32.97	$0.68
Northern N	$34.75	16.00	12.00	375	$35.12	−$0.37
Northern O	$36.85	16.50	13.00	300	$37.16	−$0.31
ConFab P	$32.10	14.00	14.00	1250	$32.50	−$0.40
Western Q	$36.44	14.00	16.00	30	$37.32	−$0.88
Western R	$39.05	14.00	18.00	25	$39.58	−$0.53
Western S	$34.52	14.00	14.00	40	$35.04	−$0.52
Western T	$35.62	14.00	15.00	40	$36.17	$0.55

Table 6
Regression analysis for front axle assemblies

Predictor	Coefficient	Standard error	*t*-Statistics	*P*-value
Constant	−1.828	2.838	−0.644	0.529
Length	1.514	0.187	8.111	0.000
Thickness	1.126	0.078	14.37	0.000
Volume	−0.0021	0.00072	−2.919	0.010

$S = 0.971$; $R^2 = 95.4\%$; adjusted $R^2 = 94.5\%$
Analysis of variance

Source	d.f.	SS	MS	*F*-statistics	*P*-value
Regression	3	311.1	103.7	109.9	0.000
Error	16	15.1	0.944		
Total	19	326.2			

Front axle should cost = −1.828 + 1.514(length) + 1.126(thickness)−0.0021(volume).

Table 7
What rear axle assemblies should cost

Model	Price	Length (cm)	Thickness (mm)	Volume	Should cost	Difference
Acme A	\$35.00	25.00	12.00	400	\$35.51	−\$0.51
Acme B	\$34.30	25.00	13.00	750	\$35.01	−\$0.71
Acme C	\$38.70	25.00	14.00	125	\$38.15	\$0.55
Baker D	\$24.20	16.00	8.00	25	\$23.90	\$0.30
Baker E	\$29.30	18.00	12.00	25	\$29.30	\$0.00
Baker F	\$33.04	20.00	14.00	15	\$33.12	−\$0.08
Baker G	\$30.34	20.00	10.00	15	\$29.90	\$0.44
Baker H	\$35.50	22.00	15.00	25	\$36.07	−\$0.57
Baker I	\$41.42	24.00	19.00	20	\$41.48	−\$0.06
MMS J	\$30.20	19.00	13.00	125	\$30.82	−\$0.62
MMS K	\$38.17	19.00	14.00	100	\$31.72	\$6.45
MMS L	\$37.10	19.00	20.00	125	\$36.46	\$0.64
Northern M	\$30.90	22.00	11.00	500	\$31.07	−\$0.17
Northern N	\$34.80	24.00	12.00	375	\$34.51	\$0.29
Northern O	\$36.00	24.00	13.00	300	\$35.60	\$0.40
ConFab P	\$33.30	24.00	14.00	1250	\$32.85	\$0.45
Western Q	\$42.28	27.00	16.00	30	\$42.29	−\$0.01
Western R	\$43.40	27.00	18.00	25	\$43.92	−\$0.52
Western S	\$40.54	27.00	14.00	40	\$40.64	−\$0.10
Western T	\$42.24	27.00	15.00	40	\$41.45	\$0.79

Table 8
Regression analysis for rear axle assemblies

Predictor	Coefficient	Standard error	*t*-Statistics	*P*-value
Constant	0.157	0.836	0.188	0.853
Length	1.087	0.038	28.39	0.000
Thickness	0.806	0.045	17.98	0.000
Volume	−0.0037	0.00039	−9.641	0.000

$S = 0.507$; $R^2 = 99.2\%$; adjusted $R^2 = 99.0\%$
Analysis of variance

Source	d.f.	SS	MS	*F*-Statistics	*P*-value
Regression	3	494.8	164.9	641.5	0.000
Error	16	9.6	3.2		
Total	19	498.9			

Rear axle should cost = 0.157 + 1.087(length) + 0.806(thickness)−0.0037(volume).

(again, see Fig. 6):

best-practice = 0.216 + 0.967(expected price).

Fig. 6 illustrates the relationship of the wheel & axle modules' actual prices to the best-practice line. Northern O lies below the best-practice line, while the other 19 lie above the line and represent potential cost reductions for the OEM.

Potential for improvement can be estimated relative to the market and the best practice. The last column in Table 11 compares the actual price to the best-practice price. In cases where the potential is quite large (Acme A, Acme B, Acme C, MMS K, and MMS L), the potential sources for cost improvement can be tracked back to subcomponent costs that were themselves well above the market estimate (Fig. 7). In revisiting the Sourcing Decision Matrix, Fig. 8 shows those same modules in the upper-left quadrant and suggests that while quality is likely to be high (in this hypothetical example, why else would they still be a supplier?) there is a lot of room for improvement on cost metrics. This analysis simply helps add direction and focus to efforts to improve their costs.

3.2. Supplier strategies: LPP sensitivity analysis

As illustrated in Table 12, a supplier like Northern O is significantly below both the market and best-practice lines and for all practical purposes should be a benchmark. Without LPP, Northern O may have held back cost reduction efforts in anticipation of across-the-board reduction mandates. With LPP, Northern O is not pressured for further cost reductions ahead of the market.

Table 9
Actual price, should costs, value add, and expected price

Model	Actual price	Wheel assembly	Front axle assembly	Rear axle assembly	Value add[a]	Expected price[b]
Acme A	$131.46	$41.88	29.01	35.51	$8.64	$115.04
Acme B	$130.10	$43.15	29.40	35.01	$7.01	$114.56
Acme C	$162.15	$57.68	34.86	38.15	$12.44	$143.14
Baker D	$105.01	$42.64	28.32	23.90	$9.36	$104.23
Baker E	$120.67	$48.76	32.82	29.30	$10.96	$121.85
Baker F	$137.88	$58.80	35.10	33.12	$12.63	$139.64
Baker G	$135.00	$63.02	32.11	29.90	$12.43	$137.45
Baker H	$151.01	$67.10	37.71	36.07	$13.96	$154.84
Baker I	$157.15	$60.02	42.23	41.48	$14.27	$158.00
MMS J	$110.52	$42.35	30.71	30.82	$9.76	$113.65
MMS K	$128.81	$44.55	34.92	31.72	$10.62	$121.81
MMS L	$143.11	$46.07	43.13	36.46	$11.94	$137.61
Northern M	$105.87	$36.75	32.97	31.07	$7.58	$108.37
Northern N	$121.00	$42.64	35.12	34.51	$9.35	$121.62
Northern O	$121.83	$45.52	37.16	35.60	$10.33	$128.60
ConFab P	$110.50	$43.74	32.50	32.85	$4.66	$113.76
Western Q	$165.17	$71.40	37.32	42.29	$14.95	$165.95
Western R	$180.11	$80.83	39.58	43.92	$16.31	$180.64
Western S	$181.11	$88.10	35.04	40.64	$16.18	$179.97
Western T	$184.53	$90.00	36.17	41.45	$16.56	$184.17

[a]Estimate based upon 10% of material costs less $0.005 \times$ volume.
[b]Sum of component should costs and value add.

Table 10
Market price regression analysis

Predictor	Coefficient	Standard error	*t*-Statistics	*P*-value
Constant	7.433	9.170	0.81	0.428
Expected	0.960	0.066	14.60	0.000

$S = 7.30625$; $R^2 = 92.2\%$; adjusted $R^2 = 91.8\%$
Analysis of variance

Source	d.f.	SS	MS	*F*-statistics	*P*-value
Regression	1	11375	11375	213.1	0.000
Error	18	961	53		
Total	19	12335			

Actual price = 7.433 + 0.960(expected price).

In Fig. 9, Acme C's price of $162.15 is significantly above the expected price ($143.14), the market price ($144.81), and the best-practice price ($138.60). If used appropriately, the LPP model can now serve as the basis for data-driven discussions. Acme C can be given the opportunity to explain why they are above the market price and best-practice price. Is it over engineering? Are a tier two supplier's subcomponents prices out of line? LPP would not identify the underlying problem or cause but would simply provide focus and direction to identifying it.

If it is determined that Acme C needs to change its parts' content and/or pricing, then in there are three possibilities for moving the Acme C's price to or below the best-practice line. We refer to these possibilities as *supplier strategies*, represented by the three arrows in Fig. 9. Exploring the strategies is a form of sensitivity analysis. For example, arrow #1 drops straight down and therefore this strategy requires only a change in price. The strategies represented by arrows #2 and #3 require content and price changes. Below we briefly discuss all three strategies. A more rigorous, mathematical presentation is explored in the appendix.

#1. Acme C can drop the price by $23.55 and reach the best-practice line. This solution is easy if the supplier can afford it and further review suggests it. However, many suppliers might question whether it is possible to lower cost while maintaining the same level of performance, quality, and content (see Sherefkin, 2003).

#2. The content and therefore the expected price can be lowered, if at the same time the amount of the actual

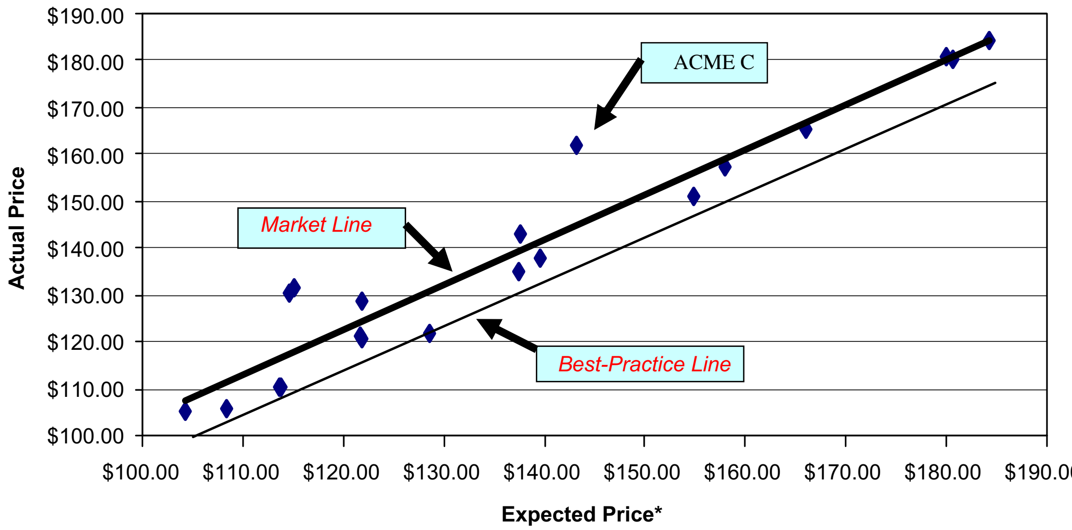

Fig. 6. LPP model for the wheel & axle modules.

Table 11
Actual price compared to market and best practice

Model	Actual price	Expected price	Market price	Actual-market	Low 25%?	Best practice	Actual-best practice
Acme A	$131.46	$115.04	$117.84	13.62	No	111.43	20.03
Acme B	$130.10	$114.56	$117.38	12.72	No	110.97	19.13
Acme C	$162.15	$143.14	$144.81	17.34	No	138.60	23.53
Baker D	$105.01	$104.23	$107.46	−2.45	No	100.98	4.03
Baker E	$120.67	$121.85	$124.38	−3.70	No	118.02	2.65
Baker F	$137.88	$139.64	$141.45	−3.57	No	135.22	2.66
Baker G	$135.00	$137.45	$139.35	−4.35	No	133.10	1.90
Baker H	$151.01	$154.84	$156.04	−5.03	Yes	149.91	1.10
Baker I	$157.15	$158.00	$159.07	−1.94	No	152.97	4.18
MMS J	$110.52	$113.65	$116.51	−5.98	Yes	110.09	0.43
MMS K	$128.81	$121.81	$124.34	4.47	No	117.98	10.83
MMS L	$143.11	$137.61	$139.50	3.61	No	133.26	9.86
Northern M	$105.87	$108.37	$111.44	−5.57	Yes	104.99	0.88
Northern N	$121.00	$121.62	$124.15	−3.15	No	117.80	3.20
Northern O	$121.83	$128.60	$130.85	−9.02	Yes	124.54	−2.71
ConFab P	$110.50	$113.76	$116.61	−6.11	Yes	110.20	0.30
Western Q	$165.17	$165.95	$166.70	−1.53	No	160.65	4.52
Western R	$180.11	$180.64	$180.80	−0.69	No	174.86	5.25
Western S	$181.11	$179.97	$180.15	0.96	No	174.21	6.90
Western T	$184.53	$184.17	$184.18	0.346	No	178.27	6.26

Table 12
Best-practice price regression analysis

Predictor	Coefficient	Standard error	*t*-statistics	*P*-value
Constant	0.216	5.925	0.040	0.973
Expected	0.967	0.047	20.40	0.000

$S = 1.79149$; $R^2 = 99.3\%$; adjusted $R^2 = 99.0\%$
Analysis of variance

Source	d.f.	SS	MS	*F*-Statistics	*P*-value
Regression	1	1335.1	1335.1	416.0	0.000
Error	3	9.6	3.2		
Total	4	1344.7			

Actual price = 0.216 + 0.967(expected price).

What Wheels "Should Cost"

Model	Price	Length	Diameter	Volume	"Should Cost"	Difference
AcmeA	$14.00	16.00	1.45	1600	$10.47	$3.53
AcmeB	$14.23	17.00	2.00	3000	$10.79	$3.44
AcmeC	$18.45	18.00	2.55	500	$14.42	$4.03
.	.	.	.	.	.	.

What Fronts "Should Cost"

Model	Price	Depth	Thickness (Mm)	Volume	"Should Cost"	Difference
MMSL	$46.15	15.00	20.00	125	$43.13	$3.02
.	.	.	.	.	.	.

What Rears "Should Cost"

Model	Price	Height	Thickness (Mm)	Volume	"Should Cost"	Difference
MMSK	$38.17	19.00	14.00	100	$31.72	$6.45
.	.	.	.	.	.	.

Fig. 7. Sources of potential cost reductions.

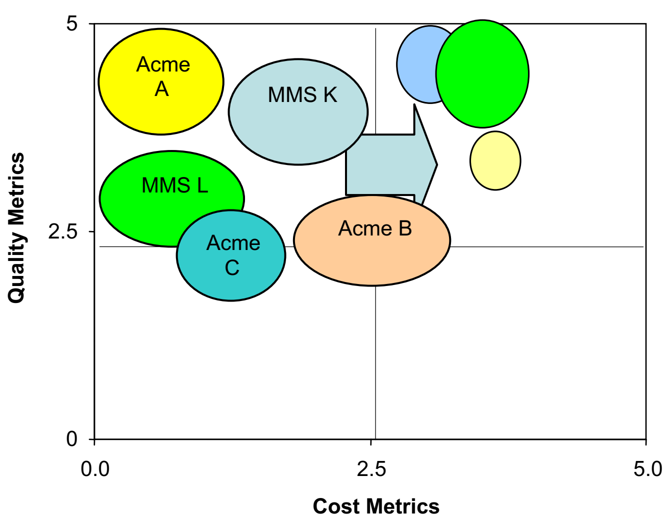

Fig. 8. Sourcing decision matrix revisited.

price drops significantly. In other words, is it possible to dramatically lower the actual price by possibly changing the sourced component's design or some aspect of its manufacturing process, or by finding a lesser component from a tier two supplier that may still meet the needs of the OEM? For example, a lighter gauge steel or less machined finish on a component may meet all OEM requirements at a lower price to the supplier. In some cases, product requirements may not allow such a substitution. If possible, however, this strategy represents a win/win situation for the OEM and the supplier.

#3. The content and therefore the expected price can be increased, if at the same time the amount of the actual cost increase to the supplier is insignificant. In other words, is it possible to dramatically increase the content and only slightly increase the price? Freiesleben (2004, p. 52) notes that his findings "show unambiguously that better quality increases pricing options when other factors remain constant." Similarly, we can argue here, "that a better content rating increases pricing options when other factors remain constant." Again, some product requirements may not allow for such a substitution but when possible, this strategy represents a win/win situation for the OEM and the supplier.

4. Managerial implications

LPP is a very powerful tool and if used appropriately can lead to significant cost savings and improved buyer/supplier relationships. If used inappropriately, then LPP has the risk of hurting the buyer/supplier relationship. A foremost consideration is remembering that the "P" in LPP stands for performance. Therefore, utmost care is needed in defining meaningful performance metrics. Is performance defined by quality, content, component costs, or all three? Do the "should costs" reflect performance? If performance metrics become too cost driven at the expense of other factors, then suppliers have little incentive to focus on the quality and content aspects of performance. Already, some suppliers see an OEM emphasis on putting cost reduction above quality (see Wernle, 2004).

However, if used properly, LPP can be very effective at focusing the efforts of an OEM to develop its supply chain in a mutually beneficial way. LPP is collaborative in that it looks at the network rather than just one dyad. It is collaborative in that it can use the network to not only focus on areas where improvement is needed but also use the network (e.g., the benchmarks, the tier two cost understanding, etc.) to help suppliers adjust prices, processes, and designs to better fit the market. These

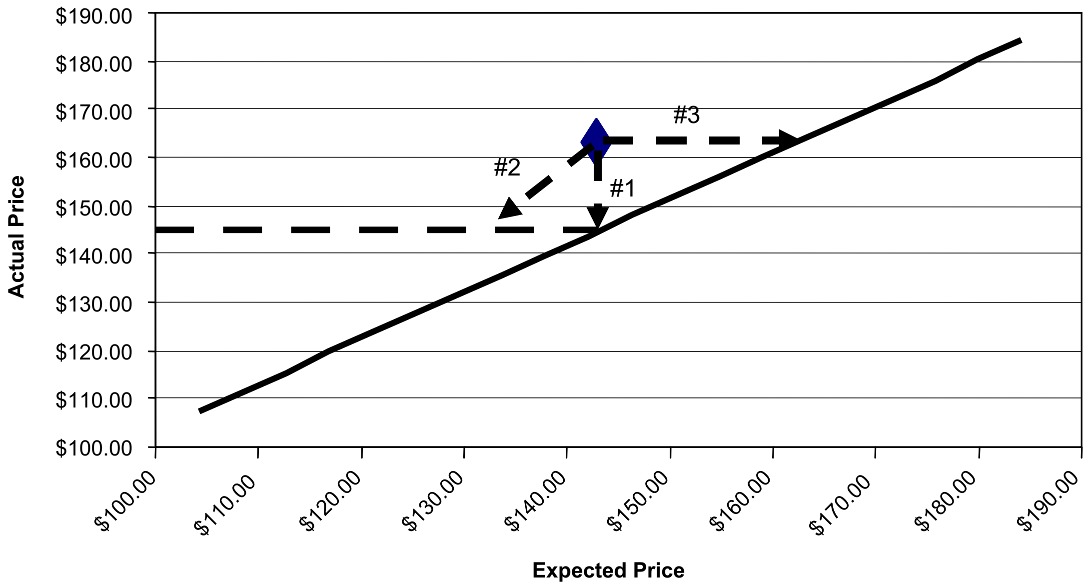

Fig. 9. Supplier strategies: moving Acme C to best practice.

product and process improvements benefit all entities in the supply chain.

Sustainable competitive advantages at all levels in the supply chain come from continuous product and process improvement rather than short-term leveraging of market clout. Simple across-the-board cost reductions fail to focus efforts where they are most needed or would result in the most significant improvements. Without reward for unilateral initiatives, suppliers potentially capable of better cost performance might simply hold back efforts to improve performance or reduce costs and react to across-the-board demands for cost reduction rather than proactively seeking leading edge improvements.

Many buyer/supplier relationships are moving beyond the adversarial mode of an arm's length relationship. Cooperation in sharing data and collaboration in product/component design is increasing, thus making the understanding of component and subcomponent cost drivers a more realistic possibility. Although many OEMs source similar components for a family of end items that range across a content/performance/quality index (i.e., "good," "better," and "best"), many do not take the opportunity to leverage the relationships and visibility that their position within the network affords them. Firms sourcing from a wide network of suppliers can benefit from an approach that allows them to focus their cost improvement efforts. Where sourcing from a variety of suppliers, such a focused approach should help the OEM to determine the market tradeoffs between cost and performance within their supply base. Viewing their suppliers in terms of this tradeoff would help the OEM begin a focused discussion with those suppliers seemingly under achieving from a cost performance perspective and hopefully help them learn from the benchmark performance of the best-practice suppliers.

Even in situations where the OEM has significant marketplace clout, the use of more focused cost reduction strategies will provide more assurance to the better suppliers that their proactive efforts to improve their performance will be recognized in terms of their competitive position in the supply network of the OEM.

LPP's backbone is regression analysis. The results of the regression models are only valid if the regression model assumptions are met. If the model is ill-defined in any fashion, then the results are questionable. Although LPP typically uses linear models, are the true relationships between performance and cost linear or nonlinear? Do the models contain all the necessary independent variables, or are some unaccounted for latent variables driving the whole pricing structure? What if the models do not fit well? Issues with independence of errors, normality, equal variance, and multicollinearity can raise havoc on the validity of the models. Certainly the services of a statistician are helpful in validating the regressions and therefore the final LPP model.

In all data-driven tools, the usefulness of the technique is only as good as the data supplied to it. Two invaluable questions to ask include "How accurately are the data measured?" and "How long has it been since the data have been updated?" Sherefkin (2003) reports that "Suppliers say the data are flawed, forcing them to match artificially low price targets." Specifically, he states that many suppliers claim the competitors are supplying components at a loss. Conversely, in many cases, outdated cost models, noncompetitive subcomponent supplier situations, overly engineered design specifications, poor efficiencies or just plain old inertia in the pricing of a supplier's products can be the basis for actual prices above the market line let alone the best-practice line. This approach will help provide direction and focus toward identifying those inaccuracies.

Moreover, these same types of inaccuracies can also be the underlying cause to actual prices that appear to be significantly below market prices. Obviously, OEMs cannot force other suppliers to match unrealistic expectations and care must be taken to show that a best-practice line in fact reflects just that. If a best-practice line is comprised of unrealistically or mistakenly priced components, it can be very problematic.

5. Conclusion and implications for future research

This paper described linear performance pricing (LPP), and demonstrated how it can be used to efficiently provide needed focus to supply cost reduction efforts within the context of modern supply chain networks. The paper demonstrates how LPP uses a series of regression analyses to competitively link tier one purchased component content and performance attributes to their cost drivers and subsequent tier two supplier component cost. Although widely used throughout the automotive industry in the US and Europe, little discussion of LPP is found in the literature. To promote a better understanding of LPP, we presented a detailed example and discussed the managerial implications of the approach. We believe that the benefits gained by using LPP include transparency of cost drivers, internal/external resource optimization, design optimization leading to lower cost of goods sold, better communication between tiers, and more focused negotiations throughout the entire supply chain network. LPP also allows firms to better negotiate initial costs for components of new products as well as help focus efforts to negotiate reduced costs for currently sourced or newly redesigned components. Like all data-driven tools, practitioners need to ensure that the most accurate data are available and that the tool is used appropriately.

Several areas for future research can be highlighted. First, while this procedure has been demonstrated in the automobile industry where OEMs hold a position of significant power over many of their suppliers, the generalizability of the process needs to be considered in other industries where the distribution of power is more balanced or even skewed toward the supplier.

Second, this approach is based upon cost/performance relationships where the variance can be explained by product or practice characteristics whose metrics can be agreed upon by both buyer and supplier. While more often than not these metrics will be specific to the situation, identifying and leveraging any commonalities between situations where LPP might be applied and establishing effective approaches to identifying them in practice will be a concern for future applications.

Third, development of a conceptual model that incorporates LPP into the strategic management of a supply chain would be of great interest to academics and practitioners. The modeling development needs to consider what is the most effective way to use LPP to mutually benefit the OEM and the suppliers.

Finally, as in any emerging area of research, a broad-based empirical study that measures the use and effectiveness of LPP across various industries is needed. In addition to quantifying usage rates by industries, the study should investigate how LPP has changed the performance of the OEMs and the suppliers. And, how has LPP changed the relationships among the entities in the supply chain?

Appendix. LPP sensitivity analysis

This appendix presents a sensitivity analysis of the relationship between an actual price and the best-practice line. The analysis involves strategies #1, #2, and #3, represented by the arrows 1, 2, and 3 in Fig. 9. The three strategies are quantified below with a single equation. Let:

$A =$ actual price
$B =$ best-practice price

The price is acceptable if:

$$A \leqslant B.$$

If content does not change, then B does not change and the simple solution is to make A less than B (see strategy #1). However, if it is not possible to simply reduce the price, one can consider changing both the expected price and actual price. Note that changing the expected price will also change the best-practice price. The price is now acceptable if

$$A + \Delta A \leqslant B + \Delta B, \tag{A.1}$$

where ΔA is the change in actual price, ΔB the change in best-practice price.

As noted above, the best-practice price is a function of the expected price. Specifically, from the regression analysis using actual price as the dependent variable and expected price as the independent variable:

$$B = \beta_0 + \beta_1 \times E,$$

where E is the expected price.

Thus a 1-unit change in E results in a β_1-unit change in B. Let

$$\Delta E = \text{change in expected cost.}$$

Therefore,

$$\Delta B = \beta_1 \times \Delta E.$$

Substituting the above result in Eq. (A.1) yields

$$A + \Delta A \leqslant B + \beta_1 \times \Delta E.$$

$$(A - B) + \Delta A \leqslant \beta_1 \times \Delta E.$$

Letting

$$D = (A - B) = \text{amount current price is above best practice price,}$$

we have

$$D + \Delta A \leqslant \beta_1 \times \Delta E.$$

A more convenient form of the above expression is given below:

$$\Delta A \leqslant \beta_1 \times \Delta E - D. \tag{A.2}$$

Eq. (A.2) allows one to evaluate strategies #1, #2, and #3. If one changes content, then the change in expected price, ΔE, is known, and therefore the right-hand side of Eq. (A.2) is easily computed. Thus, the supplier knows how big of change in price is required to bring the new piece to the best-practice line.

Applying Eq. (A.2)

Strategy #1: Using a different part as an example, Western Q is \$4.64 above the best-practice line ($D = A - B = 165.17 - 160.55 = 4.52$). If content is not changed, $\Delta E = 0$, and using Eq. (A.2):

$$\Delta A \leqslant \beta_1 \times \Delta E - D,$$

$$\Delta A \leqslant 0 - 4.64,$$

$$\Delta A \leqslant -4.64.$$

A price reduction of \$4.64 or more (a change of −4.64 or less) brings the price to best-practice. If a straight price reduction is not possible, then a different strategy is needed.

Strategy #2: When a supplier makes a content change, is the change in ΔE accompanied with the needed change in price? Remember that Western Q is \$4.64 above the best-practice line. If a content change producing a decrease in the expected price by \$10 occurs, $\Delta E = -10$, what price is now needed? Evaluating Eq. (A.2)

$$\Delta A \leqslant \beta_1 \times \Delta E - D,$$

$$\Delta A \leqslant 0.967 \times (-10) - 4.64,$$

$$\Delta A \leqslant -14.31.$$

Western Q can meet the best-practice if the actual price is reduced by at least \$14.31.

Strategy #3: If a content change producing an expected increased price by \$10 occurs, what price is now needed? Using Eq. (A.2):

$$\Delta A \leqslant \beta_1 \times \Delta E - D,$$

$$\Delta A \leqslant 0.967 \times 10 - 4.64,$$

$$\Delta A \leqslant 5.03.$$

Therefore, if the actual price is increased by \$5.03 or less, Western Q reaches best practice.

References

Anderson, J., Håkansson, H., Johanson, J., 1994. Dyadic business relationships within a business network context. Journal of Marketing 58 (10), 1–15.

Brito, C.M., Roseira, C., 2003. A model for the understanding of supply chain networks. In: Proceedings of the 19th Industrial Marketing and Purchasing Group International Conference. Lugano, Switzerland. 〈http://www.impgroup.org/paper_view.php?viewPaper=4306〉 (accessed 1.12.06).

Damodaran, P., Wilhelm, W.E., 2005. Branch and price approach for prescribing profitable feature upgrades. International Journal of Production Research 43 (21), 4539–4558.

Evans, G.N., Towill, D.R., Naim, M.M., 1995. Business process re-engineering the supply chain. Production Planning and Control 6 (3), 227–237.

Fine, C., 2000. The clockspeed chronicles. Supply Chain Management Review 4 (2), 60–64.

Ford, D., MacDowell, R., 1999. Managing business relationships by analyzing the effects and value of different actions. Industrial Marketing Management 28, 429–442.

Ford, D., Gadde, L., Håkansson, H., Snehota, I., 2002. Managing networks. In: Proceedings of the 18th Industrial Marketing and Purchasing Group International Conference. Perth, Australia. 〈http://www.impgroup.org/paper_view.php?viewPaper=4198〉 (accessed 1.12.06).

Forza, C., Salvador, F., Rungtusanatham, M., 2005. Coordinating product design, process design, and supply chain design decisions. Part B: Coordinating approaches, tradeoffs, and future research directions. Journal of Operations Management 23, 319–324.

Freiesleben, J., 2004. How better quality affects pricing. Quality Progress 37 (2), 48–52.

Institution of Electrical Engineers, 2004/2005. Supply chain falls short. IEE Manufacturing Engineer 83 (6), 2–3.

Lambert, D.M., 2004. The eight essential supply chain management processes. Supply Chain Management Review 8 (6), 18–26.

Leek, S., Turnbull, P.W., Naudé, P., 2001. Interactions, relationships and networks—past, present and future. In: Proceedings of the 17th Industrial Marketing and Purchasing Group International Conference. Oslo, Norway. 〈http://www.impgroup.org/paper_view.php?viewPaper=223〉 (accessed 1.12.06).

McKinsey and Company, 2003. McKinsey and Company details linear performance pricing. Automotive OE Supplier News 6 (6), 5 and 8.

McKinsey and Company, 2006. Automotive and assembly glossary. 〈http://autoassembly.mckinsey.com/html/resources/glossary/1.asp〉 (accessed 15.01.06).

Meixell, M.J., Wuz, S.D., 2005. Demand propagation in the extended enterprise: a comparative analysis of product and process design policies. International Journal of Production Research 43 (20), 4169–4189.

Newman, W.R., Krehbiel, T.C., 2006. Linear supply cost models: performance, content or quality based? In: Paper presented at the Decision Sciences Institute Annual Conference. San Antonio, TX, November.

Petersen, K.J., Handfield, R.B., Ragatz, G.L., 2005. Supplier integration into new product development: coordinating product, process, and supply chain design. Journal of Operations Management 23, 371–388.

Quinn, P., 2004. IBM focuses on cutting procurement costs. Supply Chain Systems 24 (3), 30–32.

Ritter, T., Wilkinson, I.F., Johnston, W.J., 2004. Managing in complex business networks. Industrial Marketing Management 33, 175–183.

Rungtusanatham, M., Forza, C., 2005. Coordinating product design, process design, and supply chain design decisions. Part A: Topic motivation, performance implications, and article review process. Journal of Operations Management 23, 257–265.

Sherefkin, R., 2003. Consultant vexes vendors: Kearney formula has Chrysler group suppliers steaming. Automotive News 78 (6062), 1 and 46.

Wernle, B., 2004. Suppliers slam D/C. Automotive News Europe 9 (5), 3.

Yang, B., Burns, N., 2003. Implications of postponement for the supply chain. International Journal of Production Research 41 (9), 2075–2090.

Zsidisin, G.A., Smith, M.E., 2005. Managing supply risk with early supplier involvement: a case study and research propositions. Journal of Supply Chain Management 41 (4), 44–57.