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Special Issue: Strategic B2B Pricing

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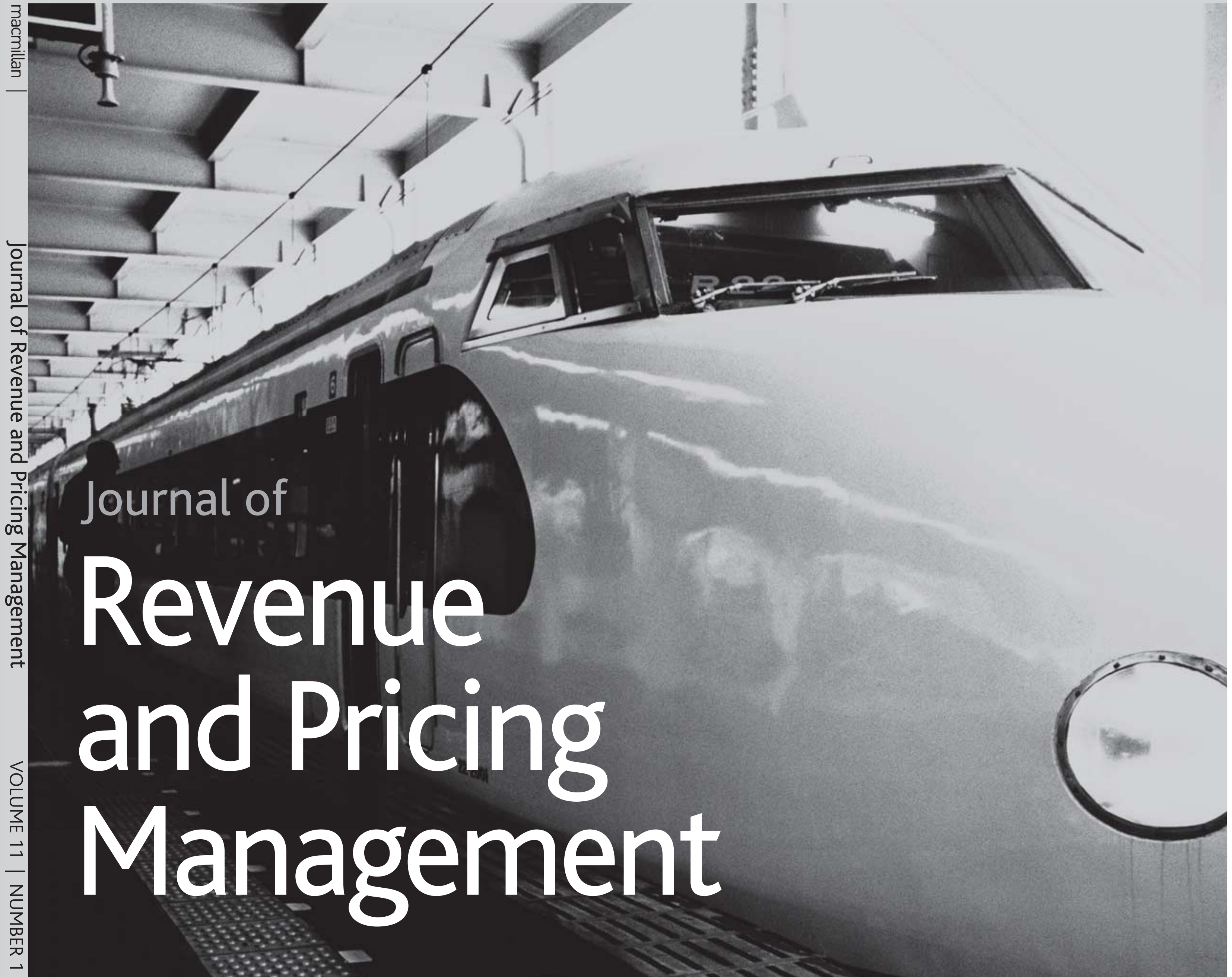

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Editorial

Strategic B2B pricing

Journal of Revenue and Pricing Management (2012) **11,** 1–3. doi:10.1057/rpm.2011.46

Marketing activities are in rapid evolution. Firms increasingly co-create values together with their customers (Payne *et al*, 2008); firms not only adapt to customer needs, they increasingly shape customer needs and alter market configurations (Storbacka and Nenonen, 2011). Firms finally increasingly need to quantify customer value and document their own contribution to the customer's profitability (Anderson *et al*, 2006). What is the role of the pricing function in this context?

Pricing is an element of the marketing mix. As such, academics and practitioners frequently treat pricing as tactical activity, *after* issues related to marketing strategy – segmentation, targeting and positioning – have been addressed.

In this special issue, we shed light on research summarizing how firms treat the pricing function in industrial companies as a strategic activity – strategic from at least two different perspectives. First, as strategic in the sense of seeing pricing as an integral part of firm strategy. Second, strategic as encompassing a resource and activity configuration that is valuable, rare, difficult to imitate, non-substitutable and embedded in the firm's organization (Barney, 1991), and thus enabling a firm to build a competitive advantage and to achieve superior profitability as a result of pricing activities.

The paper by Magnus Johansson, Niklas Hallberg, Andreas Hinterhuber, Mark Zbaracki and Stephan Liozu highlights the strategic role of pricing capabilities and shows how firms develop and organizationally embed pricing activities to gain a sustainable competitive advantage. Pricing capabilities encompass pricing setting within the firm and price setting *vis-à-vis* customers (Dutta *et al*, 2003). The quantification of customer value is a prerequisite for the development of effective pricing strategies and pricing capabilities.

Stephan Liozu, Andreas Hinterhuber, Richard Boland and Sheri Perelli examine to which extent an academically rigorous and practically relevant conceptualization of customer value is present in US industrial firms. The authors find that a large share of companies practicing cost- or competition-based pricing has an ill-defined understanding of customer value. The authors thus conjecture that the lack of an academically rigorous understanding of customer value in industrial firms may be one factor contributing to the widespread, but suboptimal (Backman, 1953) adoption of cost-based or competition-based pricing approaches.

Rafael Farres, a practicing executive, further investigates the role of customer value-based pricing in industrial companies. In this practice article, the author makes it clear that even research-intensive, innovative companies should adopt a variety of alternative pricing strategies across their product and service portfolio. The author highlights firm and environmental conditions, which make value-based pricing particularly suitable and illuminates under which conditions cost- and competition-based pricing approaches are appropriate for industrial firms.

Bradley Gale and Donald Swire illustrate how a customer value map can be constructed to compare customer-perceived benefits against purchase costs to derive an overall cost/benefit ratio of alternative products. Value maps translate product features into customer benefits and customer-perceived value, thus facilitating the adoption of customer value-based pricing, both for existing products as well as for new products. Other researchers (Sinha and DeSarbo, 1998) have shown how this map can be further developed into a latent structure, multidimensional scaling vector model with more than two dimensions. The widespread adoption of customer value maps by consultants (Leszinski and Marn, 1997; Baker *et al*, 2010) is a testimony to their high relevance in industrial pricing practice.

Tim Smith suggests treating price setting, discounting and price structure differently depending on the value and volume of transactions in industrial markets.

Magnus Johansson and Linn Andersson illustrate the implications of alternative value creation logics on pricing and customer value measurement. The authors build on Thompson (1967) and his long-linked, intensive and mediating technologies (1967) and on Stabell and Fjeldstad (1998) and their alternative business models of a value shop, a value chain and a value network; the authors then show the importance of a customer-specific assessment of customer willingness to pay in the business model of a value shop, where customer value is co-created. The main contribution of this article is the critical examination of the implications of alternative value configurations on pricing strategies and on relevant benchmarks to assess customer value.

Finally, in a Futures paper, Todd Snelgrove, a practitioner, traces the past and present of total cost of ownership (TCO) approaches and highlights in which direction TCO could evolve. As the 'sum of purchase price plus all expenses incurred during the productive life-cycle of a product minus its salvage or resale price' (Anderson and Narus, 2004), this approach is exclusively concerned with the cost side of customer value and neglects the value of customer-specific benefits (Anderson and Narus, 2004). In this article, the author shows how TCO approaches can be expanded to incorporate the value of customer-specific benefits. The contribution of this article is thus to illuminate that TCO can be compatible with customer value-based pricing.

In this volume, we further find three articles published outside this special issue. Brenda Kahn and Philip Kahn analyze city-pair airline price data and find that airlines charge a significant price premium for flights between two gateway hubs over flights between a non-gateway hub and a gateway hub, an indication that airlines may use hub-pricing to discriminate against less price sensitive international travelers.

Olivier d'Huart and Peter Belobaba use simulation to show that revenue management systems that unconstrain demand forecasts result in double counting of demand, thus overestimating forecasted demand resulting in smaller booking limits for lower fare classes than in the case of a monopolist (with perfect insight into true industry unconstrained demand). The authors point out ways to account for passenger spill between airlines.

Alwin Haensel, Michael Mederer and Henning Schmidt present a stochastic programming approach for a car rental network where capacity between alternative rental stations can be easily adjusted. The authors find that the stochastic version outperforms the deterministic version.

Industrial pricing has evolved. In light of the marketing challenges outlined above, we trust that the articles in this special issue contribute further to the strategic role of pricing in both academic research and business practice.

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Andreas Hinterhuber
Hinterhuber & Partners and
Bocconi University, Milano, Italy
E-mails: andreas@hinterhuber.com;
hinterhuber@unibocconi.it
Falkstrasse 16, Innsbruck, Austria

Stephan M. Liozu
ARDEX Americas and Case Western Reserve
University, Cleveland, Ohio
E-mail: Sliozu@case.edu
Ardex Drive, Aliquippa, Pittsburgh, USA

Research Article

Pricing strategies and pricing capabilities

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Magnus Johansson[a], Niklas Hallberg[a], Andreas Hinterhuber[b,c], Mark Zbaracki[d] and Stephan Liozu[e,f]

[a]Institute of Economic Research, School of Economics and Management, Lund University, Sweden; [b]Hinterhuber & Partners, Innsbruck, Austria ; [c]Bocconi University, Milan, Italy; [d]Richard Ivey School of Business, Ontario, Canada; [e]Ardex America Inc., Aliquippa, Pennsylvania, USA; and [f]Weatherhead School of Management, Case Western Reserve University, Cleveland, Ohio, USA

Magnus Johansson holds a PhD from the School of Economics and Management, Lund University and has worked with strategic analysis and planning within the IT, telecom, automotive and general industry.

Niklas Hallberg is Assistant Professor at the Institute of Economic Research at Lund University (Sweden).

Andreas Hinterhuber is Partner of HINTERHUBER & PARTNERS (Innsbruck, Austria) and long-term Visiting Professor at Bocconi University (Milan, Italy).

Mark Zbaracki is an associate professor in General Management at the Richard Ivey School of Business (Canada).

Stephan Liozu is President and CEO of Ardex Americas and PhD in Management candidate at Case Western Reserve University, Weatherhead School of Management (Cleveland, Ohio).

Correspondence: Magnus Johansson, Institute of Economic Research, School of Economics and Management, PO Box 7080, 220 07 Lund, Lund University, Sweden
E-mail: a.magnus.johansson@gmail.com

ABSTRACT This article explores the intersection of pricing strategies and pricing capabilities by summarizing four distinct streams of research. By doing so, it provides insights into the challenges involved in implementing value-based pricing strategies as well as the generic challenges of building pricing capabilities. It also outlines the strategic importance of pricing capabilities.
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Keywords: pricing strategies; pricing capabilities; value-based pricing; capabilities; resources

INTRODUCTION

This article provides a summary of four different research streams at the intersection of pricing strategies and pricing capabilities. It considers how firms struggle with implementing value-based pricing strategies, how this is reflected in capabilities of the organization and, finally, the general and strategic aspects of pricing capabilities.

Pricing strategies here refers to generic approaches to pricing based on cost, competition or customer value that firms apply (Cavusgil *et al*, 2003; Ingenbleek *et al*, 2003). Cost-based pricing focuses on the cost bases of products and services, competition-based pricing on observations of competitor prices whereas value-based pricing utilizes the value that a product or service delivers to customers.

Pricing capabilities (Dutta *et al*, 2002; Dutta *et al*, 2003) covers the organizational processes and mechanisms of pricing and, thus, how resources are *deployed* (Amit and Schoemaker, 1993) in association with pricing. Pricing capabilities are thus directly linked to the field of strategy and the resource-based view (RBV).

Pricing strategies, in the form of pricing approaches, are mostly associated with the pricing and marketing-oriented literature, which has rather extensively covered the topic (see for instance Nagle and Hogan (2006) and Hinterhuber (2008)). In particular, value-based pricing has received significant attention as it is claimed to be the most profitable approach to pricing (Cannon and Morgan, 1990; Anderson and Narus, 1998). However, the distinction between various pricing approaches as well as research that deals with the implementation of value-based strategies indicate the need to address the topic of pricing strategies from the perspective of the processes and routines as well as the resources involved. Therefore, this article aims at bridging the areas of pricing strategies and pricing capabilities, but also to provide additional insights into each area.

This article is organized as follows: we first summarize key literature on value-based pricing and the implementation of value-based pricing strategies. We then present the results of a recent qualitative study describing distinctive features of firms adopting cost-based, competition-based and customer value-based pricing strategies. We discuss aspects related to the organizational transformation toward value-based pricing and identify key capabilities involved. Next we identify the building blocks of pricing capabilities and the managerial challenges involved. Finally, following a qualitative research among industrial companies, we discuss the strategic importance of pricing capabilities.

The article summarizes four different empirical studies from various industries. The first section applies both a qualitative and quantitative approach. The second and fourth sections rely primarily on a qualitative approach, whereas the third section is based on an ethnographic study. The primary qualitative nature of the studies of this article reflects its focus at the intersection of two fields, that of pricing strategies and that of pricing capabilities.

IMPLEMENTING VALUE-BASED PRICING STRATEGIES, ANDREAS HINTERHUBER

Despite its benefits, value-based pricing approaches are adopted only by a minority of companies. Research indicates that more than 80 per cent of companies base their pricing decisions primarily on costs, or on prices of competitors (Hinterhuber, 2008). Previous research has uncovered the factors that prevent companies from adopting value-based pricing (Hinterhuber, 2008).

These findings were based on a two-stage empirical approach: first, in a qualitative research, the phenomenon of implementation of value-based strategies was explored with groups of business executives participating in pricing workshops. The result of this qualitative stage was then used to develop a questionnaire that was tested upon a significantly larger and more stratified population. Cluster analysis is used to summarize the results of this quantitative research stage.

Based on a survey of 81 executives representing a range of B2B and B2C industries in Germany, Austria, China and the USA, five main obstacles to the implementation of value-based pricing strategies were identified: lack of capabilities in value assessment; deficits in value communication; lack of effective market segmentation; deficits in sales force management; and insufficient senior management support. These findings are summarized in Table 1 (adapted from Hinterhuber, 2008).

PRICING ORIENTATION IN INDUSTRIAL MARKETS, STEPHAN LIOZU

Of three main orientations to pricing in industrial markets – cost-based, competition-based

Table 1: Implementing value-based pricing strategies

Main obstacles	*Manifestation*	*Best practice*
Value assessment	Lack of methods, tools or information to quantify customer value	Customer value is quantified with robust empirical research such as conjoint analysis, expert interviews or value-in-use assessments
Value communication	Communication encourages customers to fixating on price Communication centers around product features and technical product characteristics	Communication discourages customers from fixating on price Communication translates key product features into customer benefits or business impact
Market segmentation	Market segmentation is intuitive or based on easily observable but ineffective criteria	Needs-based market segmentation drives marketing strategy
Sales force management	Lack of incentive schemes and guidelines to encourage sales force to focus on value	Sales force has capabilities, guidelines and motivation to focus on value. Training and monitoring systems are in place. Discounting is not encouraged
Senior management support	Senior management is mainly interested in top-line growth or market share and does not encourage a focus on value	Senior management provides vision, context and incentives to implement value-based pricing

and customer value-based – most marketing and pricing scholars consider the latter as the superior approach for setting prices in business markets (Cannon and Morgan, 1990; Monroe, 1990). However, few industrial firms have adopted it. Marketing literature is silent about how organizational and behavioral characteristics of industrial firms may affect adoption of a pricing orientation and, more specifically, value-based pricing. Semi-structured interviews with 44 managers of small to medium-size US industrial firms yielded insights into firm pricing orientations, processes and decision-making patterns (Liozu *et al*, 2011). We identified five organizational characteristics common to firms implementing value-based pricing: the ability to face deep transformational change, the role of champions as transformational leaders, the creation and diffusion of organizational capabilities, the building of organizational confidence to fuel the transformation, and the design of center-led and specialized teams of experts supporting the firm's pricing process. Figure 1 illustrates these organizational characteristics while Figure 2 summarizes organizational capabilities for value-based pricing.

BUILDING PRICING CAPABILITIES, MARK ZBARACKI

One of the fundamental challenges for a firm is how to arrive at the right price for its products. The value a firm creates with its products can be determined by the difference between the buyer's willingness to pay and costs for the firm to produce the product. How that value gets

Figure 1: Experiental and transformative learning.

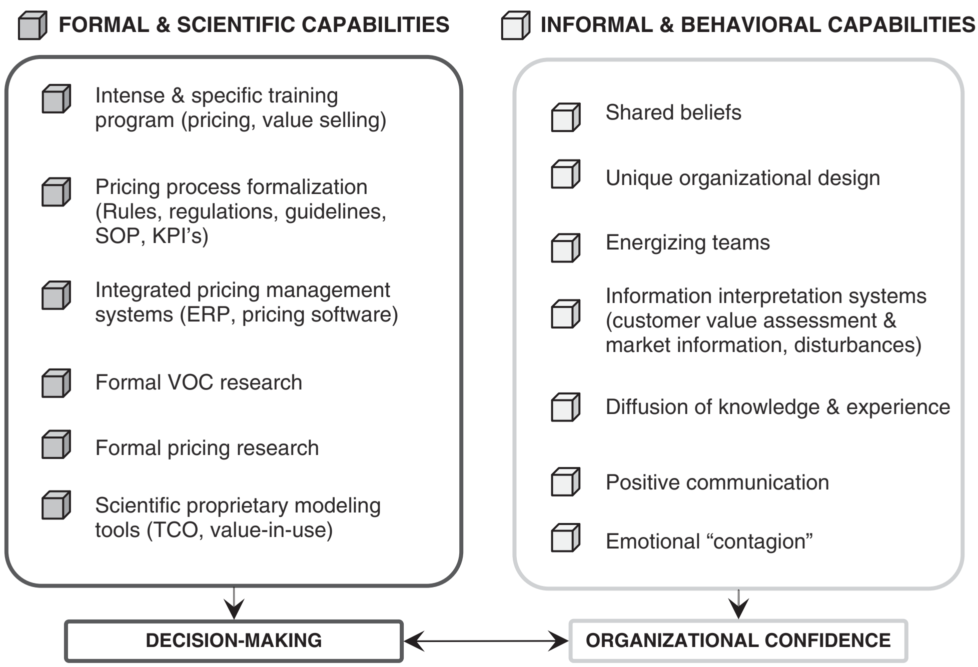

Figure 2: Organizational capabilities for value-based pricing.

allocated, however, depends on the price the firm settles at. If a firm sets its price too low, then the customer garners more than its share of the value. If the firm sets the price too high, then the firm may garner more value for the products it sells, but loses sales. Only by accurately understanding the pricing playing field can a firm arrive at the right price for its products.

Until recently, standard pricing theory has followed a myth of costless price changes (Bergen *et al*, 2003), assuming that firms can readily change their prices. In fact, arriving at the right price requires resources – often significant resources – as firms respond to market conditions (Zbaracki *et al*, 2004). Because of this myth, most companies make two mistakes. One mistake is treating pricing as a tactical activity – a response to local market conditions. In practice, effective pricing requires capabilities – human capabilities in knowledge, skills and techniques; systems capabilities in data, hardware and software; and social capabilities in communication, organization and authority (Dutta *et al*, 2003). A second mistake is assuming that they can easily purchase these capabilities. Managers often assume that if they hire the right people or purchase the latest technology, they can overcome their pricing difficulties. All too often they find that their efforts to improve pricing run-up against the barriers of the organization.

Here we address the further managerial challenge of how to begin to develop the capabilities required to set prices effectively. We begin with the problem of how to understand market forces. We argue that developing the capabilities requires assessing the firm to determine which people are essential to setting prices and understand how those people matter to pricing decisions. Based on a 2-year ethnographic study, we show how competing perspectives from different individuals can lead to different market perceptions (Zbaracki and Bergen, 2010). We argue that people hold competing partial, but coherent models of pricing. To develop pricing capabilities, a manager needs to identify those different models and determine how resource investments will shape the models – and hence market perceptions – of the different individuals holding those models. The framework we present makes pricing at once a strategic, a managerial and a tactical problem.

THE STRATEGIC RELEVANCE OF PRICING CAPABILITY, NIKLAS HALLBERG

This qualitative, interview-based, case study of pricing capability in the European packaging industry examines the process and mechanisms whereby pricing capability (Dutta *et al*, 2003) affects product market value appropriation (MacDonald and Ryall, 2004). Pricing-related challenges illustrated by the five cases included in the study ranged from keeping track of and setting consistent prices for up to 5000 different products spread across almost a thousand different customers, gaining relevant market and product-related information in novel and highly idiosyncratic pricing situations, and controlling the personal discretion of employees involved in pricing decisions.

The results of the case study show that firms commit to complex configurations of assets, routines, activities and pricing policies, which enable value appropriation through the ability to discriminate prices, and leverage firm-specific demand and cost conditions. The main function of the assets and routines that were deployed in the pricing process was to enable the information and control necessary for the execution of pricing activities and the successive implementation of pricing policy. Hence, information about production costs and the willingness to pay of customers, and the control with which the pricing process was managed, was found to be an important driver of product market value appropriation. This indicates that pricing capability is of strategic relevance because it enables the firm to overcome external and internal information asymmetries (see Coff, 1999; Makadok and Barney, 2001) that prevent it from setting prices that maximize returns to product market strategies. Pricing capability thus allows firms to appropriate a larger share of the created value by setting prices that match the perceived benefit of products in specific customer segments (price discrimination), the overall demand elasticity in the market (price elasticity leverage), and the focal firm's cost structure (operating leverage).

The RBV attributes performance differentials to immobile and heterogeneous resources that have intrinsically different levels of efficiency (Peteraf, 1993). Hence, some resources are superior to others in that they allow the firm to produce at a lower economic cost or provide products with a higher perceived benefit (Peteraf and Barney, 2003). Firms with marginal factors will perform at break-even while firms with superior resources can earn economic rents. The theoretical position adopted by the RBV thus suggests that pricing capability is not a strategically relevant factor in itself, but rather that price is jointly determined by firm-level value creation in the first step, and by market economics and industry structure in the second step (see Besanko *et al*, 2010, p. 364). This notion of firm pricing capability as a non-strategic factor is inconsistent with the notion that firms could be making consistently good or bad pricing decisions because of the differential levels of pricing capability they have in place. Hence, the broader theoretical issue concerns the fact that contemporary strategy theory has only to limited extent addressed the question of how product market value appropriation, and ultimately firm profits, might be affected by firms' appropriation abilities (see Brandenburger and Stuart, 1996, 2007).

While industrial organization economics (for example, Bain, 1956; Tirole, 1988) and the competitive forces framework (Porter, 1980) assumes rivalry restraints on product markets, factor markets are assumed to be efficient and firms are portrayed as identical in terms of their ability to identify and exploit these market opportunities. Almost as a mirror image of Porter's competitive forces framework, the RBV portrays firms as heterogeneous in terms of their expectations of the value of resources in strategic factor markets (Barney, 1986; Makadok and Barney, 2001) while the same firms are assumed to be homogeneous in terms of their ability to identify viable product market prices, bargain and, ultimately, appropriate value. This potentially problematic asymmetry in how firm resources and capabilities are linked to the processes of creating and appropriating economic value has to a certain extent been addressed by research stressing the relationship between firms (and the unique ways of creating and appropriating value in these relationships) as an important unit of analysis for understanding firm performance. This research includes the relational view (for example, Dyer and Singh, 1998; Kale *et al*, 2002; Dyer and Hatch, 2006) and the added value approach to business strategy (for example, Brandenburger and Stuart, 1996, 2007; Lippman and Rumelt, 2003; MacDonald and Ryall, 2004; Ryall *et al*, 2008; Adegbesan, 2009). However, despite progress in identifying the determinants of successful inter-firm collaboration and the necessary conditions for value appropriation, there still remain important questions concerning the firm-level factors, such as pricing capability, that determine the distribution of value in exchange relationships.

CONCLUDING DISCUSSION

The distinction between cost, competition and value-based pricing strategies provides us with a framework with which to understand and categorize different types of pricing practices. Different types of pricing approaches, and a transition towards, for instance, a stronger dependence on value-based pricing, provide highly interesting settings in which to study utilization of resources and organizational processes and routines. Pricing capabilities, on the other hand, is a key concept in order to understand the organizational and strategic challenges involved in pricing, through its focus on different types of resources and the way that the organization deploys them.

This article has illustrated the importance of combining these two areas. This is most apparent in the second section, which outlines capabilities involved in value-based pricing activities. However, cost, competition and value-based approaches are not mutually exclusive.

Implementing a value-based pricing strategy, with all the challenges it involves, is largely a general price capability-building process, which is discussed in the third section of this article.

Furthermore, the extensive organizational challenges involved in the transition toward value-based pricing illustrated in this article underline that pricing is an organizational effort. This can also be seen in the application of quality models on pricing such as organizational pricing maturity or six sigma pricing (Sodhi and Sodhi, 2005). When recognizing that pricing is an organizational effort, the routines and processes, and thus the capabilities, become fundamental factors in being successful with pricing.

To sum up, this article has highlighted the obstacles of moving towards value-based pricing strategies. It has also outlined five organizational characteristics of firms moving towards value-based pricing as well as the generic challenges involved in building pricing capabilities. Finally, it has provided insights into the strategic importance of pricing capabilities. Thus, this article links the fields of pricing strategies and pricing capabilities, and thus explores an important area at the intersection of pricing approaches and pricing practices versus resource utilization and organizational routines and processes.

However, further research dedicated at exploring the intersection of pricing strategies and capabilities is necessary. Such research should not be limited to the development of capabilities but also to resources (cf the discussion of distinctions and dependencies in Makadok, 2001) in association with various pricing practices. In addition, as this article is mainly concerned with pricing in business to business settings, additional research at the intersection of pricing strategies and capabilities in consumer industries is called for.

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Research Article

The conceptualization of value-based pricing in industrial firms

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Stephan M. Liozu[a], Andreas Hinterhuber[b], Richard Boland[a] and Sheri Perelli[a]

[a]Weatherhead School of Management, Case Western Reserve University, Cleveland, Ohio, USA; and [b]Hinterhuber & Partners and Bocconi University, Milano, Italy

Stephan M. Liozu is President and CEO of Ardex Americas and PhD in Management candidate at Case Western Reserve University, Weatherhead School of Management (Cleveland, Ohio).

Andreas Hinterhuber is Partner of Hinterhuber & Partners (Innsbruck, Austria) and long-term visiting professor at Bocconi University (Milan, Italy).

Richard Boland is Department Chair and Professor of Information Systems Case Western Reserve University, Weatherhead School of Management (Cleveland, Ohio).

Sheri Perelli is Senior Lecturer and International Business Development Consultant, Case Western Reserve University, Weatherhead School of Management (Cleveland, Ohio).

Correspondence: Andreas Hinterhuber, Falkstrasse 16, 6020 Innsbruck, Austria .
E-mail: andreas@hinterhuber.com.

ABSTRACT The current literature is largely silent on how executives interpret the concept of value-based pricing. Although only a minority of companies adopts value-based pricing approaches, little is known about antecedents of alternative pricing approaches. We suggest this may be because of the fact that few professionals possess an understanding of value-based pricing, which is both academically rigorous as well as practically relevant. Our interviews with 44 executives in 15 US industrial firms show that those practicing value-based pricing interpret customer value in ways fully consistent with the current academic literature. Those practicing cost- or competition-based pricing, however, show a poor understanding of value-based pricing, which may explain why their companies practice cost- or competition-based approaches.

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ON THE LOW ADOTOPTION OF VALUE-BASED PRICING

Of the three main approaches to pricing in industrial markets – cost-based, competition-based and value-based – the last is considered superior by most marketing scholars (Anderson and Narus, 1998; Cressman Jr, 1999; Nagle and Holden, 2002; Ingenbleek *et al*, 2003; Hinterhuber 2004) and pricing practitioners (Forbis and Mehta, 1981; Dolan and Simon, 1996; Nagle and Holden, 2002; Fox and Gregory, 2004). But few industrial firms have adopted value-based pricing. A meta-analysis of pricing-approach surveys conducted between

1983 and 2006 reveals an average adoption rate of just 17 per cent (Hinterhuber, 2008), and cost- and competition-based approaches continue to dominate in industrial pricing practice (Coe, 1990; Shipley and Bourdon, 1990; Noble and Gruca, 1999; Ingenbleek *et al*, 2001).

Historically, pricing in general has received little attention from practitioners and marketing scholars (Malhotra, 1996; Noble and Gruca, 1999; Hinterhuber, 2004; Hinterhuber, 2008). Ingenbleek (2007) reviewed 53 empirical pricing studies and concluded that pricing literature is highly descriptive and fragmented, and that theoretical development on how price decisions are made in firms is limited.

Furthermore, the marketing and pricing literature is silent on the consequences of pricing orientations on overall company performance (Cressman Jr, 1999; Ingenbleek, 2007; Hinterhuber, 2008), as well as on how organizational and behavioral characteristics of industrial firms may affect the adoption of pricing orientation (Ingenbleek, 2007), and why value-based pricing is not more commonly adopted among industrial firms. But one of the underlying reasons may be that executives lack a rigorous understanding of the concept of value-based pricing.

Our research enquiry was designed to both address this phenomenological gap and explore managers' understanding of value-based pricing in their own words. We designed a qualitative inquiry based on semi-structured interviews with managers in small and medium-sized US industrial firms that have successfully adopted value-based pricing as a pricing orientation and with managers in similar firms that have not. By probing the 'lived worlds' of these executives, we hoped to generate a grounded theory about the organizational practices that contribute to or hinder the implementation of value-based pricing strategies in industrial markets and to gather information about managers' understandings and perceptions of the concept of value-based pricing.

Our results suggest that more than 40 per cent of executives lack an understanding of value-based pricing which is at the same time academically rigorous as well as practically relevant. This lack is especially pronounced in firms practicing cost- or competition-based pricing approaches, where the concept of value-based pricing is typically confused with the concepts of total cost of ownership (TCO), value added, competitive advantage or other concepts. Our results also suggest that firms practicing value-based pricing mostly define the concept of customer value in ways that are fully consistent with current academic research: either as customer maximum willingness to pay or as the cost of the customer's best competitive alternative plus the value of any company-exclusive differentiating features.

THEORETICAL FOUNDATION

Our work was informed by pricing literature focused on firm pricing orientation, on value-based pricing theory and also on the definition of value in business markets.

Pricing orientation in industrial markets

The marketing and management literature is rich in studies related to market orientation and strategic firm orientation. Both streams of literature have taken a central role in discussions about marketing management and firm strategy (Day, 1994). Studies on market orientation have focused on its antecedents and its consequences for firm performance (Narver and Slater, 1990; Jaworski and Kohli, 1993; Slater and Narver, 1994; Kirca *et al*, 2005). Jaworski and Kohli (1993) define market orientation as 'an organization-wide generation of, dissemination of and responsiveness to market intelligence', and Narver and Slater (1990) describe its three components as customer orientation, competition orientation and interfunctional coordination. Strategic orientation is defined as the strategic direction taken by a firm to 'create the proper behavior for the continuous superior performance of the business' (Narver and Slater, 1990). The prolific literature on market and strategic orientation strongly influenced the advancement of the modern marketing concept by providing firms with behavioral and organizational perspectives on how to achieve sustainable above-average performance.

Consistent with the lack of interest by marketing scholars in researching the pricing field (Malhotra, 1996; Noble and Gruca, 1999; Hinterhuber, 2008), the notion of pricing orientation in firms has not been appropriately defined and explored. Only a handful of academic papers have discussed pricing orientation in business markets. In 2008, Hinterhuber made a strong contribution to the topic by conducting a broad and comprehensive review of 2 dozen surveys conducted between 1983 and 2006. The meta-analysis revealed the adoption rates of alternative pricing approaches (cost-based, competition-based and value-based) in business markets and showed that the competition-based approach continued to dominate in industrial pricing.

A managerial pricing orientation 'deals with decisions relating to setting or changing prices. It also includes price positioning and product decisions introducing new pricing points to the business unit's product or service mix' (Smith, 1995). Different firms adopt different pricing strategies: The current literature classifies pricing strategies into cost-, competition- and customer value-based approaches (Shapiro and Jackson, 1978; Cavusgil *et al*, 2003; Ingenbleek *et al*, 2003), based upon whether firms primarily consider costs, competitive price levels or data on customer willingness to pay in their price-setting decisions. We also adopt this classification in our empirical analysis.

Value-based pricing theory and the definition of value in business markets

Most researchers conceptualize value as a function of the benefits that the buyer receives, which researchers then compare with the costs incurred to obtain these benefits. Researchers, however, disagree both on which elements to include in the benefits component of value and on how to treat the cost component – more specifically, the acquisition costs – in the customer value function.

In terms of the benefit component, some researchers confine benefits strictly to quality (for example, Sivakumar and Raj, 1995), whereas others take a much broader view: Anderson and Narus (1998) consider value not only in terms of economic benefits received, but as the sum of all benefits, including social, service and other benefits, received by the customer from a firm's offering. Clearly, risk reduction is one of these intangible benefits. Various studies (for example, Jackson *et al*, 1995) indicate that one of the issues industrial buyers face is the risk of evaluating existing and new products/services. For the evaluation of services the aspect of risk is even more pronounced. Sellers thus create value for their customers by reducing the uncertainty and risks of product/service performance.

In terms of the cost component, conceptually, researchers interpret the role of costs and its impact on customer value in two different ways. According to Flint *et al* (1997); Walter *et al* (2001) and Zeithaml (1988), customer value is the net difference between perceived benefits and sacrifices. Flint *et al* (1997, p. 171), for example, define a customer's value judgment as 'the customer's assessment that has been created for them by a supplier given the trade-offs between all relevant benefits and sacrifices in a specific use-situation'. In microeconomic terms, customer value here is the difference between the consumer's willingness to pay and the actual price paid, that is, consumer surplus or the excess value retained by the consumer. The difficulty of this approach to defining economic value lies in the fact that price is part of the definition: each time researchers consider alternative approaches to value delivery and pricing strategy, value to the customer will necessarily change.

A second line of thought defines customer value differently: Forbis and Mehta (1981), Golub and Henry (2000), Nagle and Holden (2002), and Priem (2007) define value to the customer as the customer's value threshold – the sum of the combined accrued benefits that accrue as a result of purchasing a given offering. According to Nagle and Holden (2002, p. 74), 'A product's economic value is the price of the customer's best alternative – the reference value – plus the value of whatever differentiates the offering from the alternative – the differentiation value'. Bowman and Ambrosini (2000) define customer value as 'value is use', as the specific qualities and benefits perceived by customers in relation to their needs and expectations. Priem (2007, p. 219) refers to this conceptualization as 'consumer benefit experienced' and illustrates the application of this concept also in business-to-business relationships (Priem, 2007).

This broad conceptualization excludes the acquisition costs of the product or service from the computation of value.

On the basis of these contributions we define customer value as the customer's maximum willingness to pay. This view corresponds to the microeconomic term of a customer's reservation price, the price at which the consumer is indifferent to buying and not buying (Moorthy *et al*, 1997). Wang *et al* (2007) suggest that reservation price is not a single price but a range of values, where the lower bound indicates the price at which the consumer certainly buys the product, the midpoint the price at which the consumer is indifferent, and the high end the price at which the consumer will no longer buy the product (Wang *et al*, 2007). The price point at which the customer is truly indifferent is close to the average value between the extreme ends (Wang *et al*, 2007).

We further suggest that customer value is a multidimensional construct. In summary, customer value is equal to the maximum amount a customer will pay to obtain a given product or service, in other words, the price at which the customer is equally indifferent to purchasing and to foregoing the purchase.

A summary of alternative definitions of value-based pricing methodologies of the current literature is given in Appendix B.

METHODS

Methodological approach

We conducted a qualitative study using semi-structured interviews to develop a grounded theory (Corbin and Strauss, 2008) about how managerial understandings of alternative pricing approaches and other organizational factors affect the adoption of a pricing approach in industrial firms. The use of qualitative research is warranted as our research, interested more in words than in numbers, aims at exploring context-dependant causal relationships (Maxwell, 2005). We aim to gain a better understanding of how managers in these firms make pricing decisions and what roles they play in the firm's pricing process. Grounded theory is an explorative, iterative and cumulative way of building theory (Glaser and Strauss, 1977). The main features of this approach involve constant comparison of data and theoretical sampling (Corbin and Strauss, 2008). Constant comparison is a rigorous method of analysis that involves intensive interaction with the data (Maxwell, 2005) to contrast emerging with already-emergent ideas and themes. Simultaneous collection and processing of data (Lincoln Yvonna and Guba, 1985, p. 335) leads to the generation of firmly grounded theory. Theoretical sampling refers to ongoing decisions about whom to interview next, and how. As the constant comparison of data-yielded insights about our phenomena of interest we were able to obtain broader comparative and deeper personal narratives about pricing experiences and adjusted the sample in response to emerging ideas and themes.

Sample

Our sample consisted of 44 managers in 15 small and medium-sized US industrial firms

(Appendix C). We focused on small and medium businesses as they represent a vast majority of the US firm population as indicated by the Small Business Administration. Furthermore, as prior publications related to value-based pricing mostly focused on large-size organizations, we wanted to inquire on how small and medium businesses organized for pricing. Relying on the principle researcher's professional network and on advice from the Professional Pricing Society, we identified over 36 small and medium-sized US firms in three industries: building materials, transportation products and resins and plastics products. Managers in each firm were contacted for initial qualification with respect to their pricing orientation. The intention was to then request participation in the research project from small and medium firms that used the three basic pricing orientations. Fifteen of the qualified companies agreed to participate in our study.

Seven firms were small as defined by the Small Business Administration 2007 size standards by industry (www.sba.gov/size) as having between 50 and 380 employees; and eight were medium-sized, having between 900 and 2200 employees.

Six firms (18 interviews) adopted cost-based pricing, five (14 interviews) used competition-based pricing and four (12 interviews) relied on value-based pricing. Two to four interviews were conducted at each firm. Respondents included 15 CEOs or top executives, 18 sales and marketing managers with full or partial responsibility for pricing, and 11 finance and accounting managers with decision-making authority. The firms were geographically diverse, as interviews were conducted in 10 US states.

Data collection

The primary method of data collection was semi-structured interviews conducted over a 3-month period from April to June 2010. Thirty-seven interviews were conducted in person at the respondents' place of employment, and seven were conducted by telephone. The interviews, averaging 60 + min, were digitally recorded and subsequently transcribed by a professional service.

We focused on managers' experiences in making pricing decisions and in participating in the firm's pricing process. We asked open-ended questions to elicit rich and specific narratives and used probes when needed to clarify and amplify responses. Respondents were first invited to talk about themselves, their backgrounds and their work. We then asked them to describe their specific experience with the most recent pricing decision made in their firm or a very recent meeting during which pricing was discussed or a pricing decision was made. Third, we asked them to focus on the most significant pricing decision made in their firm over the past 12–24 months and to describe that experience in great detail. For both questions we used probes to provoke specific details about the pricing process. Finally, we asked respondents about their experience with pricing innovation and value-based pricing. The overall goal was to elicit experience-based practitioner perspectives on the organizational factors that influenced their firm's pricing orientation.

Data analysis

Consistent with a grounded theory approach, data analysis commenced simultaneously with data collection. The audio recordings of each interview were listened to several times and the transcripts of each interview read repeatedly. Three stages of rigorous coding then ensued. First, all of the transcripts were 'open-coded', a process that requires the researcher to identify every fragment of data with potential interest (commonly called 'codable moments', Boyatzis, 1998). Open coding, which can be compared with a brainstorming process for the analysis of data (Corbin and Strauss, 2008), requires detailed line-by-line readings of each transcript. We read each transcript four times to ensure capture of all codable moments, which were documented on index cards. Manual coding on cards allowed the researchers to nearly 'memorize' the data and to capture the essence and richness of the general themes and trends emerging from the voice of the respondents. We identified and labeled (Boyatzis, 1998) 2554 such words, phrases or longer sections of text in the 44 interviews. These 'codable moments' were sorted and assigned to pre-existing or new categories that included similar excerpts from other interviews. In a second phase of coding (axial coding) these categories were further refined as we compared and contrasted them, a process that resulted in the emergence of patterns and themes. During the axial coding phase we reduced the number of categories to 92. Finally, in the third phase of the coding process (selective coding), we focused on key categories and themes that generated our findings as shown in Appendix A.

FINDINGS

Respondents were asked to share their understanding of value-based pricing. Our intention was to stay away from theoretical definition and to give them the latitude to create their own conceptualization so that we could gather impressions about how they perceived the construct.

Finding 1: The conceptualization of value-based pricing varies from firm to firm as well as within firms.

The conceptualization of value-based pricing varied from firm to firm as well as within firms. Tables 1 and 2 illustrate this phenomenon by presenting the understanding of value-based pricing from the executives in firms that use it. A full list of conceptualizations is presented in Appendix E.

Finding 2: The conceptualization of value-based pricing is often confused with added-value programs and TCO initiatives.

Respondents working in firms that used cost-based pricing tended to confuse the concept of value-based pricing with other concepts such as value-added strategies, business model value, and value of augmented services. Table 3 presents the results of the coding of the value-based pricing understanding or definition and the

Table 1: Understanding of value-based pricing by top management of companies practicing value-based pricing

CEO – small equipment manufacturer	It's understand your value of the product compared with the best competitor, and then put a price tag on that specific value, which is delivered by a feature, and find out what – how valuable that specific feature is … a very good tool for that is conjoint analysis.
President – plastic packaging manufacturer	It means to take the product and break it down in terms of the value that it's providing for the customer, and determining what is … the cost of this benefit and what is the value that the customer will give us, that is the price, for that particular thing.
CEO – building materials and tools manufacturer	Value-based pricing would be the combination of understanding the level of innovation and productivity that I bring to the customer versus his alternative. That would be value-based pricing. And … if I can calculate the significance of the innovation (and) the level of productivity that it allows the customer, then I can explain the value of my product and the pricing that comes along with it.
Business Director – engineered chemicals manufacturer	What does it mean to me? … what is the maximum economic advantage you can bring and still drive that change versus the next best alternative … Drive the change through the supply chain, and yet keep as much as possible to be successful in both of those. Drive the change and keep the rest.

Table 2: Understanding of value-based pricing at different levels of companies practicing value-based pricing

CEO – building materials and tools manufacturer	Value-based pricing for me would be the combination of understanding the level of innovation and productivity that I bring to the customer versus his alternative. That would be value-based pricing. And … if I can calculate the significance of the innovation (and) the level of productivity that it allows the customer, then I can explain the value of my product and the pricing that comes along with it.
Pricing Manager – building materials and tools manufacturer	Would be in your customer's mind, the value of what you bring to them with that product and brand … The brand carries more value. The product carries a little bit more value, and so there is a premium that they can charge. Now what that premium is, is highly, in my mind, unscientific. That is almost art as it is science. Now I am sure they can measure that art by charging different amounts on different things and seeing the response rate'.
CFO – building materials and tools manufacturer	I think you would take the side of the customer and you would assess as a customer what value (they) get from (the) supplier? And value … means the equation between … the things that I get that I have an appreciation for and how much it is worth ….

Table 3: Themes emerging from the conceptualizations of value-based pricing

Themes used to define value-based pricing	*Number of mentions*	*Managers in firms using value-based pricing*	*Managers in firms using cost-based pricing*	*Managers in firms using competition-based pricing*
Value-added products and services	10	1	7	2
Value of products and products features	7	2	2	3
Customer productivity gains and savings (TCO)	6	2	2	2
Willing-to-pay and gettting paid for what the product is worth	6	3	2	1
Premium pricing	5	0	2	3
Need-based segmentation	4	3	1	0
Perceived customer value	4	2	1	1
Differentiation versus competition	4	0	3	1
Market price and what the market can bear	3	0	0	3
Overall value proposition	2	0	2	0

major themes that emerged from this exercise. Ten respondents, most of whom worked for firms that adopted cost-based or competition-based pricing, related value-based pricing to the concept of value-added products or services. The following quotes illustrate this phenomenon:

> I would say I could assume what I think that it is, which is the – value-based

> pricing, meaning … there is some sort of value added to what I am doing to this product that allows me to charge X that it cost me plus what I think I am adding the value, and that equals Y, the selling price. (Finance and accounting manager in a firm that adopted cost-based pricing)

> I think the term, and probably a bit more generic in nature, is really to just best understand what your overhead structure is and how to ensure that you are receiving and maintaining the appropriate margins associated with what you have in play. Yeah, I really think that we establish what we think to be a firm understanding of what our overhead structure is, and what the marketplace and industry that we serve, we establish certain boundaries around that. And to me, that is what is going to bring that value basis to how we operate. Value add is an interesting point, but it is an area that is proven to be successful for us as we have gone through, and once again, it is the introduction of anything that we have that I think, from a contract manufacturing standpoint, gets us further down the food chain to supply our customers for what they need. (CEO of a firm that adopted competition-based pricing)

Finally, other managers often associated the concept of value-based pricing with the implementation of the TCO approach, as illustrated in the following excerpts:

> I think, when I hear that term, value-based, I think in terms of are there performance characteristics that the product that we're selling and we do that all the time. I mean with engine oils, you try to show the customer if they buy a semi-synthetic engine oil from us and they pay $7.80 a gallon, versus paying $6 a gallon from one of these independent guys that are bathtub blenders, if we can extend their drain interval – like maybe with the cheaper oil, they're going to have to drain their oil every 10 000 miles. Well if they buy a semi-synthetic oil from us, through oil analysis, we might be able to prove to them they can run that oil for 30 000 miles instead of 10 000 miles. (Sales manager in a firm that adopted cost-based pricing)

> Very simply. I understand it as trying to determine exactly what a company's current cost is for something and then going [to] present a solution … it's trying to understand the customer's full cost and then making pricing decisions based on the customer's cost rather than on your own internal [cost]. I guess maybe that's a better way to say it. It's pricing based on the customer instead of based on you. So that's my understanding of it. (CEO of a firm that adopted competition-based pricing)

TCO is the 'sum of purchase price plus all expenses incurred during the productive life-cycle of a product minus its salvage or resale price' (Anderson and Narus, 2004). TCO is exclusively concerned about the cost side of customer value and thus neglects the value of customer-specific benefits (Anderson and Narus, 2004; Piscopo *et al*, 2008).

Finding 3: Firms practicing value-based pricing conceptualize value in ways that are largely consistent with the current literature on customer value.

A vast majority of managers practicing value-based pricing defined value as either customer benefits over the best competitive alternative or as customer willingness to pay. This definition is thus fully in line with the current literature, namely Forbis and Mehta (1981), Golub and Henry (2000), Nagle and Holden (2002), and Priem (2007). Table 4 provides an overview by firm pricing orientation. Highlighted in gray are the conceptualizations that correspond to the current literature.

Table 4: Definitions of value-based pricing, by firm pricing orientation

Firm pricing orientation	*Conceptualization of 'value-based pricing'*								*TOTAL*	*Academically grounded definitions of value (%)*
	Customer benefits over best alternative	*WTP*	*Low price*	*Company costs cost plus value of benefits*	*Product performance/ benefits*	*Unclear*	*Maximum benefit for money*	*Premium*		
Cost	4	3	1	3	3	2	2	—	18	39
Competition	2	5	—	2	—	2	—	3	14	50
Customer value	9	2	1	—	—	—	—	—	12	92
Total	15	10	2	5	—	4	2	3	44	57
Per cent	*37*	*24*	*5*	*12*	*0*	*10*	*5*	*7*	—	—

Finding 4: Firms practicing cost- or competition-based pricing conceptualize value in ways that are largely inconsistent with the current literature on customer value.

Firms practicing cost-based or competition-based pricing approaches, on the other hand, define value-based pricing in ways that are to a large extent inconsistent with the current literature on pricing. These companies define value-based pricing as 'low price', as 'company costs plus the value of customer benefits', as 'product performance', as 'maximum benefit for a given amount of money', as 'premium price', and so on. Only about half of the companies practicing competition-based pricing and about one third of the companies practicing cost-based pricing define value as suggested by the current academic literature (see Table 4).

Thus, a sound, academically rigorous understanding of value-based pricing is present in about 43 per cent of companies practicing cost- or competition-based pricing. That these companies have a sound understanding of customer value is, however, not sufficient to enable them to actually adopt value-based pricing. A lack of capabilities, organizational resources, top management sponsorship and other factors prevent them from actually implementing this method.

DISCUSSION

We begin by contrasting the current definition of value-based pricing in the literature with the conceptualization of value-based pricing by practicing executives in US industrial companies. We then highlight role of top executive in guiding their team through the internalization process. We conclude with implications for research and for practice.

How the literature defines value-based pricing

From a theoretical standpoint, customer value is defined in broadly two ways by the current literature: either as customer maximum willingness to pay (customer reservation price) or as the difference between benefits and price (customer surplus). Under these two broad perspectives, the pricing literature offers a broad array of concepts related to value-based pricing (see Appendix B): the current literature in fact contains 12 different definitions of value-based pricing. The proliferation of the number of available value-based pricing methodologies may have created confusion in the mind of managers engaged in the study the field of value-based pricing.

How practicing executives in industrial markets conceptualize value-based pricing

The executives we interviewed showed wide variation in their understanding of the concept of value-based pricing. On average, only about 60 per cent of executives interpret value-based pricing in ways that are consistent with current academic literature: the others interpret value-based pricing as low-cost pricing, as premium pricing, as cost-plus pricing, as TCO, or in other ways not supported by the literature. We find, however, that the degree of understanding varies substantially with overall firm pricing orientation: executives in firms with a value-based pricing orientation show a good understanding of value-based pricing, whereas executives in firms with a cost-based or competition-based pricing orientation predominantly misinterpret the concept of value-based pricing.

The role of champions in leading the organizational transformation

Organizational pricing champions are critical drivers of the conceptualization and internalization of value-based pricing, as well as the organizational transformation that is required. Champions mobilize the organization by energizing teams, making resources and knowledge available, providing continuous emphasis and focus on the pricing orientation, and by being willing to learn from failures to break down organizational and behavioral barriers (Chakrabarti, 1974). Champions also make sure that the firm knowledge foundation is strong and anchored on the appropriate concepts. Champions also lead by creating a learning environment grounded in knowledge exploration and exploitation that might generates superior organizational intelligence (March, 1999). Here the roles of top executives championing the pricing projects, as well as of pricing managers leading the tactical and operational implementations are critical. They both have to spend the appropriate amount of time on being trained on the appropriate concepts to, in turn, train managers and decision makers in their organizations that will be exposed to value-based pricing.

Implications for practice

Pricing is increasingly seen as key lever for improving profitability: Companies such as General Electric, DuPont, SAP as well as small and medium-sized companies aim to move toward value-based pricing approaches, dedicating substantial resources to improving the effectiveness of pricing processes (see, for example, Stewart, 2006). The adoption and internalization of value-based pricing requires, first of all, an academically rigorous and practically relevant understanding of the concept of value-based pricing. This research shows that this understanding is in no way granted: The interviews we conducted with 44 managers – including 15 CEOs or members of the management board – in US industrial firms suggest that more than 40 per cent of managers seem to be unable to correctly define customer value-based pricing. Conversely, <60 per cent define value-based pricing rigorously. A lack of understanding of what customer value is seems to prevent companies from implementing value-based pricing strategies, despite of the fact that these companies may recognize that these strategies are sub-optimal. Already 6 decades ago, academic researchers have recognized that cost-based pricing strategies lead to sub-optimal profitability: Backman (1953, p. 148) observes: '… the graveyard of business is filled with the skeletons of companies that attempted to base their prices solely on costs'.

For practicing managers these results thus suggest that the implementation of value-based pricing approaches requires an academically grounded view of customer value, which is solidly anchored across multiple hierarchical layers and across organizational units. Investments in training, communication, knowledge and capability building in pricing are pre-requisites for implementing value-based pricing strategies.

Implications for research

Anderson and Narus (1998) raise the question: 'How do you define value? Can it be measured? … Remarkably few suppliers in business markets are able to answer those questions. And yet the ability to pinpoint the value of a product or service for one's customer has never been more important'. Our research supports these concerns: few managers are able to define customer value rigorously, which may explain why these managers revert to cost- or competition-based pricing approaches.

Research on pricing processes is still comparatively rare. Dutta *et al* (2002, 2003) and Hallberg (2008) examine pricing processes and highlight the role of pricing capabilities in enabling superior company performance. The current literature further advocates the superiority of value-based pricing approaches over cost- and competition-based pricing approaches (Cannon and Morgan, 1990; Monroe, 1990; Ingenbleek *et al*, 2003), implicitly assuming that managers know what value-based pricing is.

The contribution of this study to this literature consists in highlighting the role of knowledge on customer value as antecedent of pricing capabilities. Value-based selling and the development of pricing capabilities require a sound understanding of customer value, which is by no means warranted.

LIMITATIONS AND DIRECTIONS FOR FURTHER RESEARCH

The findings presented in this article should be considered in light of several limitations that may impact their generalizability. Our sample of small and medium industrial firms was small (15), not randomly selected and limited to the United States of America. The sample included only firms in three industrial sectors building products, transportation products and plastics and chemicals. A larger and more diverse sample and one including other sectors such as IT or pharmaceuticals may have yielded different findings.

Although special attention was given to the potential risks of researcher bias, it is important to mention that the principal researcher has significant experience in and knowledge about industrial pricing, in particular, value-based pricing. However, great effort was made to remain self-reflective about these risks (Corbin and Strauss, 2008) by using open-ended questions to elicit rich, unstructured narratives of respondents' experiences (Maxwell, 2005, p. 22), interpretations and understanding of pricing events and firm activities.

Our findings suggest that one reason why value-based pricing approaches are not more widely adopted by industrial firms is that value-based pricing is not fully understood by executives, who fail to distinguish this concept from others such as competitive advantage, low prices, cost-plus and total cost of ownership.

We thus call for more research probing the question of antecedents and consequences of alternative pricing approaches. Further studies probing the understanding of alternative pricing approaches, specially the understanding of value-based pricing, across other industries – including industries practicing revenue or yield management – would further contribute to the current literature. In addition, the question of financial consequences of alternative pricing approaches has been to a large part (for an exception, see Ingenbleek *et al*, 2010) been ignored. Also here, more research is needed.

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APPENDIX A

Table A1: Themes and sub-themes definitions

Themes *Sub-themes*	*Definition* *(Derived from informant's interview data)*
Organizational confidence	
People development	Firm's people development activities (coaching, performance review and so on) used to build confidence.
Internal beliefs	Employee's beliefs in the firm's products, technology, value and business model.
Communication	Communication systems and techniques used to promote change management and build confidence.
Success stories	Firm's use of business wins and success stories to build momentum, increase buy-in and build confidence.
Resilience	Sales and marketing employees's resistance to customers' pricing objections, courage to stand firm and stay the course.
Data accuracy	Data accuracy as decision making support to provide confidence in the pricing decision.
Energy	Energizing team to increase confidence level.
Champions	
Vision	Champions providing vision to the organization about pricing and value strategies.
Emphasis	Champions providing emphasis and support throughout the organization.
Commitment	Champions committing to the strategy and the change management initiative.
Driver	Champions being the driver of initiatives and programs.
Change	
Change management	Adoption of pricing approach requires management of change.
Learning curve	Adoption of pricing approach is a leaning curve.
Journey/transition	Adoption of pricing approach is a transitional process also characterized as a journey.
Mindfulness	Realization of organizational gaps, learning from failures, being opened to new concepts.
Stimulus	Stimulus within the organization for change.
Lessons learned	Lessons learned in the areas of change management and difficult transitions.
Capabilities	
Training	Firms' training programs and activities.
Pricing training	Firms' specific pricing training programs.
Lack of training	Respondents' declared lack of training.

Table A1 *continued*

Themes *Sub-themes*	*Definition* *(Derived from informant's interview data)*
Sales force skills	Respondents' declared level of capabilities of the sales force with pricing and value selling.
Market research	Firms' capabilities in conducting formal market research programs.
Pricing research	Firms' capabilities in conducting formal pricing research.
Proprietary tools	Firms' capabilities in the development of proprietary tools and models.
Organizational structure	
Firm size and resources	Respondents' mention of size and resources as a factor influencing pricing approach.
Role specialization	Firms' team specialization in strategic areas (pricing, market research, value engineering).
Centralization	Centralization of expertise and centers of excellence.
Pricing responsibilities	Locus of responsibility in organizations.
Process formalization	Firms' declared level of process orientation and formalization.
Informal pricing review	Respondents' characterizing of the pricing review process.
Pricing process discipline	Respondent's characterization of the pricing discipline.
Rationality	
Margin targets	Use of margin targets and mark-ups to generate pricing decisions.
Cost models	Use of costs models and costing activities to generate pricing decisions.
Gut feeling and intuition	Respondents' declared factor used in making the final price point decision (gut feeling, intuition, collective intuition).
Guess and call	Respondents' declared factor used in making the final price point decision (guess, judgment call).
Knowledge and experience	Respondents' declared factor used in making the final price point decision (market knowledge, historical pricing, experience).
Scientific pricing process	Respondent's characterizing of the organization's pricing process.
Unscientific pricing process	Respondent's characterizing of the organization's pricing process.
Exogenous factors	
Competitive intensity	Level of competitive intensity and threat impacting pricing strategies and tactics.
Market turbulences	Recessions and economical crisis impacting pricing strategies and tactics.

APPENDIX B

Table B1: Identified value-based pricing methodologies in business publications

Acronym	*Value-based pricing framework*	*Year*	*Author*	*Publication*
—	Value-in-use pricing	1982	Christopher	*European Journal of Marketing*
EVC	Economic value to the customer	1981, 2000	Forbis and Mehta	*Business Horizon: McKinsey Quarterly*
EVP	Economic value pricing	1994	Thompson and Coe	*Journal of Business & Industrial Marketing*
CVM	Customer value models	1998	Anderson and Narus	*Harvard Business Review*
TCO	Total cost of ownership	1998	Ellram and Siferd	*Journal of Business Logistics*
TEV	True economic value	1999	Dolan	*Harvard Business School Cases*
EVE®	Economic value estimation®	2002	Nagle and Holden	Book – *The Strategy and Tactics of Pricing: a Guide to Profitable Decision Making*
EVA	Economic value analysis	2004	Hinterhuber	*Industrial Marketing Management*
—	The dollarization process	2004	Fox and Gregory	Book – *The Dollarization Discipline' How Smart Companies Create Customer Value and Profit from It*
CVA	Customer value accounting	2006	Gale and Swire	*The Journal of Professional Pricing*
IVA	Integrated value approach	2009	Schnell and Raab	*Pricing Advisor*
—	Value-based pricing framework	2010	Anderson, Wouters, and Van Rossum	*MIT Sloan Management Review*

Forbis and Mehta (1981); Christopher (1982); Thompson and Coe (1994); Dolan (1995); Anderson and Narus (1998); Ellram and Siferd (1998); Forbis and Mehta (2000); Fox and Gregory (2004); Gale and Swire (2006); Schnell and Raab (2009); Anderson and Wynstra (2010).

APPENDIX C

Table C1: Detailed sample information

Criteria	*Characteristics*	*Firms*
Firm size	Small	8
	Medium	7
Industry	Building products	4
	Transportation products	5
	Resins and plastics products	6
Pricing orientation	Cost-based pricing	6
	Competition-based pricing	5
	Value-based pricing	4
	Total firms	15

Criteria	*Characteristics*	*Respondents*
Functions	Executive leadership	15
	Sales and marketing	18
	Finance and accounting	11
Nature	Face-to-face interviews	37
	Phone interviews	7
	Total interviews	44
States	Pennsylvania, North Carolina, South Carolina, Oklahoma, Michigan, Massachusetts, Georgia, Wisconsin, Delaware and Kentucky	

APPENDIX D

Table D1: Detailed sample description

Firm code	*Number of employees*	*Size*	*Industry*	*Main activity*	*Number of interviews*	*Functions*	*Interview type*
Cost-based pricing							
CB1	70	Small	Plastics and resins	Industrial oil and lubricants	3	President	In Person
						Sales Manager	In Person
						Controller	In Person
CB2	125	Small	Building products	Carpet backing and geotextiles	3	VP and GM	In Person
						Sales Manager	In Person
						Controller	In Person
CB3	225	Small	Transportation products	Interior trim and composites products	3	CEO	In Person
						CFO	In Person
						VP of Automotive Sales	In Person
CB4	2000	Medium	Transportation	Railroad equipment systems	3	VP and Group Executives	In Person
						VP of Sales and Marketing	In Person
						Controller	In Person
CB5	900	Medium	Building products	Commercial windows and doors	3	President	In Person
						CFO	In Person
						VP and GM	In Person
CB6	1200	Medium	Plastic and resin	Commodity and specialty chemicals	3	CEO	In Person
						CFO	In Person
						Head of Business Unit	In Person
Competition-based pricing							
COB1	165	Small	Building products	Exterior facade products	3	CEO	In Person
						CFO	In Person
						DIR of Marketing	In Person
COB2	380	Small	Plastics and resins	Custom injection molding products	3	CEO	In Person
						CFO	In Person
						DTR of Global Sales and Marketing	In Person
COB3	50	Small	Transportation	Interior design products	2	President	In Person
						Account Manager	In Person
COB4	1200	Medium	Transportation	Advanced composites products	2	CEO	By Phone
						Global Business Manager	By Phone

COB5	900	Medium	Plastic and resins	Safety equipments systems	4	President and CEO	In Person
						CFO	In Person
						VP Sales and Marketing	In Person
						–VP of Customer Operations	In Person
Value-based pricing							
VB1	300	Small	Plastics and resins	Safety and protecting products	3	CEO	In Person
						VP of Sales	In Person
						CPM Manager	By Phone
VB2	1200	Medium	Transportation	Packaging solutions	3	President	In Person
						VP of Marketing	–By Phone
						Controller	By Phone
VB3	2200	Medium	Building products	Construction tools and consumables	3	CEO	In Person
						CFO	In Person
						Customer Foci's Manager	In Person
VB4	2000	Medium	Plastics and resins	Engineered polymers	3	Global Business Manager	In Person
						National Sales Manager	In Person
						Corporate Effectiveness Manager	By Phone

APPENDIX E

Table E1: Value-based pricing conceptualizations

Function	*Activities*	*Firms using value-based pricing*
Safety and protection products	CEO	It's understand your value of the product compared with the best competitor, and then put a price tag on that specific value, which is delivered by a feature, and find out what – how valuable that specific feature is. Again, a very good tool for that is conjoint analysis.
Safety and protection products	VP of Sales	(Company) is a company that is normally – believe it's high quality and premium products, but there is a market for products that, of course, need a high quality, but also a good price and also lower functionality. And to address this market, we address the value-based market … for different regions and also different requirements in the same applications.
Safety and protection products	Customer Process Monitoring Manager	Well, I mean value-based pricing I think is, in my mind, is simple. It is what the customer is prepared to pay based on what the product does for the customer, and that they perceive it will do for them. Okay? So if – let me give a simple example. If I am a downhill skier, I could buy 230 cm skis. I could have a really good price on 'em. And I may be a skier, but you know what? I do not downhill race. So that product does not meet my needs, so it does not matter how low the price is; I am not gonna buy it. Right?'
Packaging solutions	President	It means to take the product and break it down in terms of the value that it is providing for the customer, and determining what is – like for example, sometimes I have seen people take what is the cost of this benefit and what is the value that the customer will give us, that is the price, for that particular thing.
Packaging solutions	VP of Marketing	The term 'value-based pricing' to me would be based on any value added, things we are doing over our competitors. What are we adding to our floor price or our standard price.
Packaging solutions	Controller	I guess I would say that you would – to arrive at a price for your customer, it would be based on the value that you are providing 'em, not on any internal-cost data. And you would look at – probably go through the value that you are bringing to their business and the savings that they are gonna realize, and that would probably be the key driver as to how you price the opportunity.
Construction tools and consumables	CEO	Value-based pricing for me would be the combination of understanding the level of innovation and productivity that I bring to the customer versus his alternative. That would be value-based pricing. And how, if I can calculate the significance of the innovation, the level of productivity that it allows the customer, then I can explain the value of my product and the pricing that comes along with it.
Construction tools and consumables	Customer Focus Manager	I think the common definition that we all have is that the value-based pricing is we are pricing based on the perceived value from the customers, not based on a cost or cost plus model to the customer. Now, I think the differences get into the methodologies used to figure out what is the value to the customers versus what some other companies may do. (Company), in the past, has used certain practices like the customer acceptance test to assess whether or not the price points we are setting are in alignment with the perceived value to the customers.
Construction tools and consumables	CFO	I think you would take the side of the customer and you would assess as a customer what value do you get from this supplier? And value means it is, you know, the equation between here's the things that I get that I have an appreciation for and how much is this worth for me? So I have a certain judgment to that. And that is what it would mean for me.
Engineered polymers	Business Director	What does it mean to me? It is what is the economic – what is the maximum economic advantage you can bring and still drive that change versus the next best alternative. Okay, so it is always a next best alternative kind of thing. Drive the change through the supply chain, and yet keep as much as possible to be successful in both of those. Drive the change and keep the rest.

Engineered polymers	Corporate Effectiveness Manager	My own definition of value-based pricing is to understand the value that you deliver to your customers through your products and services, and having a pricing strategy that captures a part of that value that you deliver, which under the competitive environment, you can sort of maximize.
Engineered polymers	National Sales Manager	We talk about value-based pricing a lot, so for us what that means is we price based on several different factors that are not related in any way to the cost of the material. It is more related to how is the plastic being used? What value is that plastic – instead of as a plastic pellet, as a plastic part that is holding bearings? And so if this plastic can go into this part, which is a bearing housing, that might be worth US$4 a pound. If it goes into this simple tape dispenser, it might only be worth $2 a pound or $1 a pound or 70 cents a pound. So what we do is when we talk to customers about – when they ask us for a quote, we ask them a lot of questions. "What is the application? What are you using it for? How long do you need? How much do you need to buy? Where is it gonna go? What is the end use? What is the demands of the environment?.
Function	*Activities*	*Firms using cost-based pricing*
President	Industrial oil and lubricants	My take on value-based pricing is may be different from most. I think a lot of people talk about value from a standpoint of the things that we all do. We have trucks. We have sales people. We have technical people. So you look and say, well, you know, we have that, too. So from a true value standpoint, I honestly believe thinking for the customer on behalf of what the true savings is – I will give you a great example of it. We had a customer that by making a change saved $3 000 000. Their spend on our fluid was probably about $60 000.
Sales Manager	Industrial oil and lubricants	I think, when I hear that term, value-based, I think in terms of are there performance characteristics that the product that we are selling – and we do that all the time. I mean with engine oils, you try to show the customer if they buy a semi-synthetic engine oil from us and they pay $7.80 a gallon, versus paying $6 a gallon from one of these independent guys that are bathtub blenders, if we can extend their drain interval – like maybe with the cheaper oil, they are going to have to drain their oil every 10 000 miles. Well if they buy a semi-synthetic oil from us, through oil analysis, we might be able to prove to them they can run that oil for 30 000 miles instead of 10 000 miles.
CFO	Industrial oil and lubricants	I would say I could assume what I think that it is, which is the – value-based pricing, meaning I am going to – there is some sort of value added to what I am doing to this product that allows me to charge X that it cost me plus what I think I am adding the value, and that equals Y, the selling price.
VP and GM	Carpet backing and geotextiles	Yeah. For us, I would link that to our value add. We have our base goods that we make off our line. And now we are getting more into adding some additional value to it. We have partnered with an outside converter, and they have just recently built a line that they will now basically toll manufacture for us our value-add goods, which for us could be an adhesive. That is a big one for us.
Sales Manager	Carpet backing and geotextiles	If you are saying value-based, it is a good product at the right price delay way that you can to make them successful, yeah, I understand on time that you provide service for, and you help the customer and that. And that is what we do.
Controller	Carpet backing and geotextiles	To me, that would be looking at all – that whole bundle of services that we are providing to somebody. If we are spending time running trials to develop a product, the things that we do from an inventory standpoint to ensure that the customer never runs out, to the technical service guys that we send out periodically to help the customer processing new material. All of those things are part of what we call our SG&A, our overhead type costs and you typically do not get into a cost calculation when you are doing kind of a cost plus pricing setting. So yeah, we need to take a look at that.

Table E1 *continued*

Function	*Activities*	*Firms using value-based pricing*
CEO	Interior trim and composites products	It means trying to size up what this is worth to our customer and price it from that standpoint. So to me, that would be – I do not know what it is to you, but to me, that would say we have programs where we have a certain technology that allows our customer to realize the lower scrap rate, substantially lower than our competition. And we think it is pretty unique, and we will place some value on what that scrap rate is worth to our customer, and say we should be able to capture some portion of that premium.
VP of Automotive Sales	Interior trim and composites products	Value-based pricing just by interpreting what – to me that would be providing, depending on product, customer, the situation, something that could be priced differently for different situations – the same product – depending on the situation. Let us say a customer –I am purely just shooting at this, Stephan, but a customer that we have and some customers that have long-term agreements with would be better capable and suited to provide, I will call it better value price to them – a better value proposition to them than a smaller customer that has low volume is a payment risk – is a receivable risk and they would have a different price structure and model.
CFO	Interior trim and composites products	I understand it in terms of the value that it brings to the customer. So I guess it goes beyond just a product, but kind of the composite cost of the customer, the logistics and the scrap and what other things they have to put on top of it to make it work.
VP and Group Executive	Railroad equipment systems	I think it comes back to the philosophy of trying to understand how your product is viewed by the buyer and what are the things that are important. So it is really understanding his purchasing criteria and requirements, what does he value, what is he looking for. And understanding your market in a very profound way because then you do not leave money on the table, you are not as likely to, or your do not overprice and miss the business because you really missed what they customer's looking for. So I think that, and then understanding the competitive environment is very important, too. Not only with their prices but what is their value proposition and how does your compare with that. Because if all you do is listen to the customer, they are going to give you one dimension and it is all going to be about lower price and you have to really profoundly understand the reality from the total business perspective.
VP of Sales and Marketing	Railroad equipment systems	For me, it is what some good or service is worth to the customer. What is he willing to pay, and why is he willing to pay that? So you know, when you get in these discussions or in planning these things, how do you differentiate yourself? We have a tendency because we are engineering driven. Sometimes we have a tendency to differentiate ourselves from the view of, 'I am an engineer, and I just made this thing better.' As a sales guy, I always look to see what is cost drivers – what causes them the pain, what causes them frustration.
Controller	Railroad equipment systems	If I were to hear the term 'value-based pricing,' it would be the cost of the product plus the service that we provide to the product to make sure that it works for our particular customer's application.
CEO	Commercial windows and doors	What would be my definition of value-based pricing? Well, probably along the lines for the end user or for the customer would be, in essence, him getting the most for his money. Part of our job, as we look at it, is trying to be somewhat consultative. We are not gonna be the cheapest guy in the marketplace, but we will try to work, especially on negotiated stuff, with our clients and the whole design team. And the more information that they share, for instance, around their budgeting, the better we could offer for them. So if we know what their desired intents are, we are gonna try to not oversell them on something that is beyond what they are looking for, nor undersell them on something that is below what they are looking for. So from a value standpoint, we try to give 'em the most for their money.
VP and GM	Commercial windows and doors	When you say value-based pricing – I am not sure. I think when you say value-based pricing, I think, in my terms here at (Company) that terms are of our cost plus mentality, but I think value-based pricing, I think what you are probably talking about is understanding the value of your product in the marketplace, and then pricing appropriately.

CFO	Commercial windows and doors	I would definite it as segregating your products into different market segments for different customers, different industries, understanding the need of those industries, determining what their – the competition is for those specific niche areas, and then establishing pricing based on what the needs of the customer are versus what the competition is offering and what your differentiation is in the marketplace.
CEO	Commodity and specialty chemicals	What it means to me is getting the maximum price for the type of value that our product offers. Okay. And the way to do that is, as I said before, is truly understand the market dynamics, market trends, the customers' needs, desires, what is driving your decision.
Head of business unit	Commodity and specialty chemicals	To me a value-based pricing would be you take your costs that is up to a point, you have all your costs. That takes you to X, and then you add on top of that what is the perceived value? But then my personal comment on that through my industry experience is you have to do that. And you come up with something. Then you have your reality check of the market, meaning is that product so much better than a competitive product? That I can come up with my own perceived value, but if I do not have any validity with the market on that, I can think I can sell a product at $1, but my customers say, 'Well, that is fine, but I currently have a product here. And I pay 90 cents. And I will not pay $1 for your product.
CFO	Commodity and specialty chemicals	Um, to me, and it could be my own interpretation of this, what you are able to bring to the customer and looking at all aspects and all of whether or not there is a technical aspect, an R&D aspect, certain fit for you aspect. In other words, of your product and trying to maximize what you can get out of it with your customer, that is my view of it.

Function	*Activities*	*Firms using competition-based pricing*
CEO	Exterior Façade Products	I guess from all the education I have had, I would look at that being that you establish the value of every part of what you do, and you try to get a premium for the value that you offer to the marketplace. So you' want to make sure that you are truly getting paid for the value you offer to the market. That is how I would interpret it.
Director of Marketing	Exterior Façade Products	Would be in your customer's mind, the value of what you bring to them with that product and brand. So if Macintosh, to use consumer products, Macintosh comes in and says, 'I have got this phone. It is got a few really cool Macintosh things'. To me as a consumer, the brand carries more value. The product carries a little bit more value, and so there is a premium that they can charge. Now what that premium is, is highly, in my mind, unscientific. That is almost art as it is science. Now I am sure they can measure that art by charging different amounts on different things and seeing the response rate.
CFO	Exterior Façade Products	You know, you are selling on like the benefits and features of the products or the company, you know, and you should be getting a premium for that if there is a perceived premium for that in the marketplace.
CEO	Custom injection molded products	I think the term, and probably a bit more generic in nature, is really to just best understand what your overhead structure is and how to ensure that you are receiving and maintaining the appropriate margins associated with what you have in play. Yeah, I really think that we establish what we think to be a firm understanding of what our overhead structure is, and what the marketplace and industry that we serve, we establish certain boundaries around that. And to me, that is what is going to bring that value basis to how we operate. Value add is an interesting point, but it is an area that is proven to be successful for us as we have gone through, and once again, it is the introduction of anything that we have that I think, from a contract manufacturing standpoint, gets us further down the food chain to supply our customers for what they need where they are.
Director of Global Sales and Marketing	Custom injection molded products	That I would basically not worry – the costs are gonna be what they are. And I can say I can do it for $5.00. But if the value of this calculator is $10.00, I should sell it for $10.00, regardless. Yeah, I think, if that is the correct definition. I mean when we see the opportunity to – if someone is asking us to do something that we have three competitors who are saying it is gonna cost X to do it, and we can do it for half of that, we will not do it for half of that.
CFO	Custom injection molded products	I would think about our value added products we sell with the value add services we add into the business. But I do not get involved with the pricing of that at all.

Table E1 *continued*

Function	*Activities*	*Firms using value-based pricing*
President	Interior automotive design products	You know, I would say it is – to take a look at it from a customer's perspective in terms of value, you bring to the table to them and making sure you are getting fair value, fair dollars for what you are bringing to the table. In example of the Toyota one where you look at it and say, 'Okay, you can buy from us for 30 per cent over the material that has historically been higher aesthetic'. So if they are 30 per cent more expensive, if I can level out the aesthetics, in a sense, I should be able to charge 29 per cent premium on my material and be 1 per cent less.
Account Manager	Interior automotive design products	Well, it is, in my opinion, it is all relative to the value of your product. I mean is it an aesthetic product? Is it a performance product? It is all about perception, I think. Perceived value. You know, can you – where can you price your product according to the value that customers are going to get out of using it?'
CEO	Advanced composites products	Well, for me, what that means is looking at ultimately the benefit that the customer ultimately gets from your product, under every mechanism, not just in terms of performance, but in terms of the total value that you provide to the customer. And then turning that around and saying, "What is that ultimately worth?" Okay? And in terms of what someone is going to be willing to pay for your product.
Global Business Manager	Advanced composites products	Value-based pricing to me means that you understand what your product brings to a certain application and what value it really brings. And you are able to get the pricing that you believe the value deserves.
CEO	Safety equipment and systems	Very simply. I understand it as trying to determine exactly what the – what a company's current cost is for something and then going – presenting a solution – an alternative to that that is priced the same with higher quality or priced lower with the same – it is trying to understand the customer's full cost and then making pricing decisions based on the customer's cost rather than on your own internal – I guess maybe that is a better way to say it. It is pricing based on the customer instead of based on you. So that is my understanding of it.
VP of Sales and Marketing	Safety equipment and systems	I understand it to be – I will use it for the practical example as opposed to try to define it. Cost plus is nothing than that I want to hit 55 per cent gross margins to make my business run on all of my instrument sales, therefore, I go down and I get my standard costs once a year from manufacturing. And it is whatever it is, and I multiply that by whatever the math is to get me a 55 per cent gross margin, and that becomes my price. That would be a cost plus pricing strategy. Value-based pricing would say, 'Okay, what is the market gonna pay based on my research around talking to customers, seeing what pricing's already in the market from competition, and what my own judgment is of the value of my offering?' And I am gonna say, 'I think I can get a buck for this'. And if it costs me 95 cents to make, then my gross margin's 5 cents. If it costs me 5 cents to make, then my margin's 95 cents. But what I am gonna – I am gonna work from the customer backwards and the value proposition backwards, and I am gonna build that on.
VP of Customer Operations	Safety equipment and systems	Value – my definition of value-based pricing was – I guess a short answer would be whatever the market will bear. Forget about what our cost it. Forget about what our margin is. It is whatever the market will bear. If we have a list price $1000, and we see the market will bear $1200, $1300, $1400, that is value-based pricing. The difference between the two.
CFO	Safety equipment and systems	Well, I know that we have looked at different pricing and different costing models on activity-based costing, I would say. But, to me, value-based, I go back to we have looked at what the market will bear, and we start through this voice of customer and our product management team. So I do not really – do not have a lot of extra input into the value-based side.

Practice Article

Optimal pricing models in B2B organizations

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Rafael Farres

Agfa Graphics, Mortsel, Belgium

Rafael Farres is currently Head of Strategy for Agfa Graphics. He has been Head of Pricing for Agfa from 2005 until 2011.

Correspondence: Rafael Farres, Agfa Graphics, Septestraat 27 2640 Mortsel, Belgium.
E-mail: rafael.farres@telefonica.net

ABSTRACT This article discusses the application of value-based pricing strategies in B2B companies. It explores the conditions for implementing value-based pricing strategies in companies selling a portfolio of products competing in a variety of different market segments. The article also discusses the limits of value-based pricing strategies and suggests ways to overcome implementation pitfalls.

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Keywords: value-based pricing; B2B pricing; implementation of pricing strategies; pricing practice

INTRODUCTION

In recent years, once the opportunities for production optimization and fixed cost reductions have reached their limits, many companies have begun to look at pricing as the last lever with which to improve profits. Pricing manager has become a new function, and pricing departments have analyzed pricing in much greater detail than before. As a result, new pricing models have been implemented, with different levels of success. B2C companies have been pioneers in this area, trying to understand customer perceived value and introducing concepts such as 'value pricing'.

The term is very attractive, especially if we consider the extra revenues that pricing experts tend to predict with a value pricing approach. Not surprisingly, there has been a lot of hype around the concept. But is value pricing the ultimate model, and can it be implemented in all business situations?

In this article, we analyze this question and explore alternative pricing models and their scope in B2B companies.

VALUE PRICING SCOPE

Value pricing means setting the sales price around the value that a product can deliver to its customers rather than as a mark-up of the product cost. But how do customers perceive value? And, more specifically, do customers who buy a product to produce another one (B2B) perceive its value differently than end users who buy a product in order to use it (B2C)?

In our view, value pricing is applicable to products that have the potential of being differentiated from competitors. It is also true that value pricing techniques, such as conjoint analysis can help to highlight the product values around which companies can apply value pricing. But this is not always the case, and it may be that a company is confronted with a product that is equal or inferior to that of a competitor. In these situations, it may be necessary for the company to mirror the competitor's strategy or to closely follow its production costs, in order not to lose money.

DIFFERENCES BETWEEN B2B AND B2C PRICING

The value perception in B2B is often driven by factors that are different from those in B2C. This is because the products supplied in B2B are normally intermediate elements in a value chain from which a final product is produced the consumer. Therefore, in B2B, customers will assess a product in terms of the value it can add to their value chain. As a result, buying decisions in B2B are more objective and fact-based. Product specifications are often measurable, and customers will try to translate them into the value they can add to their value chain.

In B2C, it is the end user who defines the 'perceived' value of a product. Here, consumer buying decisions can be more subjective (based on product appearance, personal feelings and so on) than fact-based. Brand recognition and packaging have a strong influence on B2C buying decisions, and therefore advertising can play an important role. This is why in B2C the brand has much greater value than in B2B. This explains that B2C companies typically have much richer advertising budgets than B2B companies.

So, how does a company define an optimal pricing strategy? Let us analyze the different pricing options (see Figure 1).

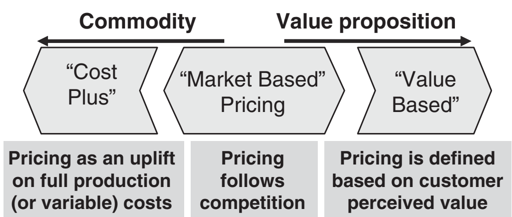

Figure 1: Basic pricing model.

VALUE PRICING

In a situation where distinct product values can be identified, value pricing can be implemented. This does not mean that the values are necessarily intrinsic to the product itself. They may reside in the service or in other elements that distinguish the offer from a competitor's.

When launching an innovative product, a B2B company has a competitive advantage. This advantage can be translated into a price that will result in a sufficient sales volume to deliver an optimal margin. The trade between price and volume is critical to achieving optimal profitability with the new product. Conjoint and price-sensitivity analysis are very good tools for achieving this.

In other situations a product may not have a competitive advantage, but a company may be able to reposition or bundle it with other products or services to differentiate the offer. In a way, this can be equivalent to launching an innovative product, in the sense that the bundle is the new product. This may enable the company to apply value-based pricing strategies. This allows companies to use value pricing as in a new product launch.

In B2B it is important to understand how to approach the customer. In most B2B situations, the business negotiation is unavoidable. In this case, training the sales force in a product's new features is key to being able to communicate value to the customer. In this situation, top-line growth incentives can be very appropriate.

But how to communicate value in B2B, where the product is an element in the customer value chain? Customers will try to compare a product with its competitors, evaluating the potential savings or additional values they can achieve. Therefore, you need to evaluate the contribution of your product to the customer's value chain. Cost of ownership analysis and ROI are therefore critical in B2B price negotiations.

MARKET-BASED PRICING

We need to differentiate market-based pricing from value pricing. It may not be possible to

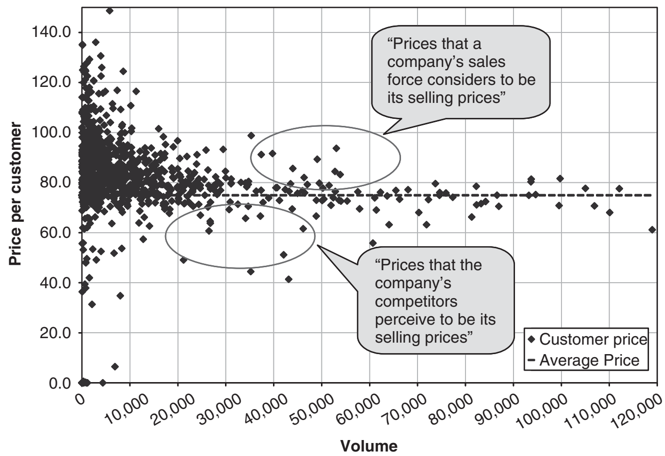

Figure 2: Pricing cloud.

differentiate all products, but they still must be sold at competitive price levels. For many products, prices are highly comparable and well known in the industry. But if a product cannot be differentiated, what then should the pricing strategy be?

The main issue in market-based pricing is to determine true market price. Most companies are confronted with price differences between customers, as a result of the historical accumulation of different price negotiations. This can be easily visualized in a graph that compares price with volume per customer (Figure 2).

What happens is that a company's competitors perceive only its lowest prices (lower circle), whereas the company, in particular its sales representatives, perceive it to be selling at average prices (upper circle). This happens because salesmen provide feedback to management only where they experience pricing problems, typically to request a lower price. Although the company sees its average price, its competitors will be convinced that its average selling prices are at the level of the lower circle in the graph. But that same company views its competitors' prices in much the same way. In other words, a company will perceive the lowest prices of its competitors, creating a distorted view of real price levels.

The only way to counteract this negative price effect is to understand one's competitors' pricing. This may require a 'competitors pricing intelligence', in order to understand under which conditions their prices are given, and why they follow certain price moves. It is also necessary to know if a competitor's prices are differentiated by segment, customer size, for strategic reasons, or as a reaction to specific competitors. A company should also consider how its pricing actions will be perceived by its competitors and to what extent it may force them to react.

Thus, the true market price for a product is in most cases higher than the price at which it is selling today.

COST PLUS PRICING

Under certain conditions, prices must be aligned with production costs. This may be determined by aggressive or even desperate competitor moves, which may force a company to set prices with extremely low margins, or even at a break-even level. Such strategies are often adopted in situations of overcapacity or underutilized production lines. Competitors must fight for volume just to survive. What is the appropriate pricing strategy in these circumstances?

First, the business environment must be understood. An analysis of the available capacity in the market versus the market requirements and estimated future trends will help a company gauge whether it makes sense to continue with a particular product or not, and what the alternatives are.

An analysis of competitors' production costs and their financial situations will shed light on the chances of potential competitors' exit or consolidation processes. Understanding this will help a company to determine the most appropriate pricing strategy.

For cost-based pricing, the following price steps are critical:

Price controlling

A pricing discipline is always important, but in this case it is critical. If prices must closely adhere to production costs, a company cannot afford to make any mistakes in implementing a pricing discipline, because they will result in a loss. Therefore, it is even more important to have the customer price conditions well documented to ensure that the agreed price is achieved in full

De-bundling products

Bundling products renders prices less transparent, because the customer and the company are comfortable with the values that the combination is providing. In a bundle, a company offers its product in association with another product or service that the customer often uses at its discretion. When prices are set close to their cost, a company cannot associate any discretionary products or services with it, as they may be overused. In a cost plus pricing scenario, everything provided should have a price, which the customer may take or leave.

Linking prices to relevant indices

The cost of some products may be partially linked to the price of a specific raw material or a currency. In these cases, a company may offer its price linked to the evolution of this index. Currencies and the most typical raw materials, such as metals, trade today in public markets, and these indexes are easily available.

Basing incentives on margin

When margins are rich, incentives based on growth are appropriate, but in cost plus, margins are small. In this case, a company's sales incentives should be based on margin. If its sells at a 10 per cent margin on average and, thanks to negotiation, a sales representative is able to achieve a 1 per cent higher price, the company's margin increases by 10 per cent, and this achievement can be rewarded.

BUT HOW LOW CAN A COMPANY GO?

In order to link prices to costs, a company must understand well its manufacturing and distribution costs; not all cost components are fixed, and some will vary under different circumstances. If the company's line is at 90 per cent capacity occupation and its fixed costs are already covered, this extra 10 per cent of production will cost very little. But where is the limit? To determine this, the company must consider its 'incremental costs'.

Incremental costs are the costs per unit of incremental production. Evaluating incremental costs requires separating the fixed-cost components, such as factory amortization and fixed labor, from those that increase with every extra unit produced, such as raw materials, energy and variable labor. Incremental costs define the lowest price limit. Below these prices the company is destroying cash.

CONCLUSIONS

Value pricing strategies are complex and require a great deal of market research to capture customer perceived values, price sensitivity and other critical factors. On the other hand, pricing strategies are strongly linked to overall company strategy, and cannot be dissociated from them.

Therefore, before defining a pricing strategy a company must have a clear picture of the market, segments, current and estimated future trends, the competitive landscape, and its products and values. Only with this information can it formulate a business and pricing strategy.

With this plan in mind, a company can define pricing strategies for each product/market-segment combination. Defining what each type of situation calls for – a value, market-based or cost plus pricing strategy – will help the company focus on the critical points of its strategy and avoid the time and costs associated with implementing the wrong one.

Value pricing techniques should be applied where they can deliver value, rather than indiscriminately over a company's entire product portfolio.

Research Article

Implementing strategic B2B pricing: Constructing value benchmarks

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Bradley T. Gale and Donald J. Swire

Customer Value Inc. 250 Park Shore Drive, Unit 701, Naples, FL, 34103, USA.

Bradley T. Gale is the founder and president of Customer Value Inc. and author of 'Managing Customer Value' (The Free Press, 1994).

Donald J. Swire is a vice president Development and Applications of Customer Value Inc.

Correspondence: Bradley T. Gale, Customer Value, Inc., 250 Park Shore Drive, Unit 701, Naples, FL, 34103, USA.
E-mail: bGale@cval.com

ABSTRACT Pricing specialists agree that businesses should price products based on *value*. Yet most companies set prices based on the *cost of their product*. Alternatively, they set prices based on the *prices of competing products*, without fully accounting for the worth of performance differences between their product and the reference products. They do not have the techniques or tools to appraise their product's value versus other products on the competitive landscape. We illustrate how to appraise a product's value based on the going rate prices of competing products *and on its performance versus these comparable products* on key purchase criteria that customers assess. We discuss how this benefits business teams by making them more market driven, customer focused and competitor savvy.

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INTRODUCTION

Pricing specialists agree that businesses should price products based on *value*. Yet, many companies set prices based on the *cost* of their product (Ulaga, 2001; Hinterhuber, 2008). Alternatively, they set prices based on the *prices* of competing products, without fully accounting for the worth of *performance differences* between their product and the reference products. Why?

In a research study aimed at identifying specific obstacles that prevent companies from implementing value-based pricing strategies Hinterhuber found that the number one obstacle was the ability to conduct an accurate *value assessment*. One respondent commented that his business team just did not have the tools to attach a financial value to their differentiated product. As Hinterhuber noted, 'If the company itself does not know the value of its products or services to customers, how does it know what to charge the customers for value?'

In this article, we provide a practical, proven and easy-to-implement solution to the problem of finding a benchmark for value: *customer value mapping*. We show how to estimate the worth of one's product based on both (a) the *going-rate prices* of the various products currently on the market *and* on (b) the *composite overall performance scores* for these products. The overall performance scores depend on how the product and comparable products perform on the key purchase criteria that buying teams use to assess alternative products and vendors. The key tool for constructing value benchmarks and visualizing the competitive landscape is a *customer value map* (Gale, 1994),[1] a scatter plot relating going-rate prices to composite overall performance scores.

Note that this approach is different from other value-based-pricing techniques where the approach is to estimate the economic consequences for the customer in using your product. Such techniques, while useful, require many assumptions about the users' processes and the costs and revenues associated with them. Further, with those techniques, the valuation is not linked to the actual array of price and performance choices available to the customer in the market. In customer value mapping, the link between going-rate prices and overall performance scores provides a solid, market-based grounding for the pricing benchmarks.

In the next section below, we describe how buying teams simultaneously choose a product and a supplier. In the subsequent section, we illustrate how to calibrate the monetary value of each product competing in a category. In the section after that, we discuss strategic pricing based on value. In the section after that, we note that when selling to business customers, supplier attributes can play a bigger role than product attributes in the customer's purchase decisions. In the penultimate section, we discuss installing a customer value appraisal and management system that follows a product through its lifecycle. We conclude by highlighting some advances in the customer value-mapping toolkit and the benefits the new techniques deliver to business team leaders.

HOW DO BUYING TEAMS CHOOSE A PRODUCT/SUPPLIER?

How do business customers decide which products to buy and which supplier to choose? In some cases they focus almost exclusively on price and buy from the vendor offering the lowest price. In most markets, however, business customers consider a variety of other factors. These non-price factors reflect their business' needs, their reasons for purchasing the product, and their organization's anticipated outcomes and experiences from selecting a supplier. Buying teams refer to these factors as *key purchase criteria*. Marketers refer to them as *key buying factors*. Price is always a factor. Yet, in many cases, sellers who differentiate their offers by outperforming the competition on the non-price attributes can justify sizeable price premiums versus basic offers.

How much is a product worth versus alternative offers? In this article we describe a customer value-mapping technique that relates going-rate prices for the products competing in a market category to the overall performance scores of the products. In order to calculate an overall measure of performance, a team needs performance scores on each of the buyer's key purchase criteria and a sense of how influential each benefit attribute is in the supplier selection process.

First, a team must identify the non-price purchase criteria that buyers will look at. In B2B markets the performance attributes relate to the overall offer the supplier provides, not just the product attributes. The B2B performance dimensions include the *product itself* (for example, quality, features, ease of use), *vendor service* capabilities (for example, lead time, on time delivery, tech support), the *customer–supplier relationship* (for example, knows our business' downstream customer needs, understands our business model, provides insights on how we can stay ahead of the market), and *the supplier's reputation* (for example, viability, an organization we can trust, industry leader).

The *product* that a purchasing team is assessing may be a physical good, a core service or a more comprehensive solution. The product-specific attributes differ by product-market category. Mining, construction and forestry companies assess industrial machines based on their power, capacity, durability, reliability, features and ease of use. Farming businesses and medical practitioners assess agricultural chemicals and prescription drugs based on measures of their efficacy and side effects. Companies looking for a supplier of information technology outsourcing services assess competing vendors based on attributes with names like *delivers on promises*, *understands business needs*, *helps you achieve your business goals* and *works with you as a partner*. In addition, buyers of capital goods often assess other costs incurred in owning and using the product, as well as purchase price. In summary, cross-functional buying teams typically assess the performance of competing offers on attributes in the product dimension and the various supplier-performance dimensions of performance – balanced against the cost dimension (price or total cost of ownership). Factors like durability and reliability, which are often treated as performance attributes in consumer markets, are sometimes assessed as part of total cost of ownership in B2B markets. For a case example (room air cleaners) that uses three cost attributes (equipment price, energy costs and consumables costs) and four benefit attributes (removes smoke, removes dust, quite and easy to use), see Gale and Swire (2006).

Business *buying teams* attempt to account for value differences among alternative offers by studying all of the important performance differences. To keep pace with their customers, *selling teams* also attempt to account for value differences. To do this they are increasingly adopting *customer value mapping* to appraise the worth, or market value, of their products. They assemble data on the performance of their product offers and the product lines of several competing vendors in a *comparative performance scorecard*. They use *customer value maps* to display and review how the going-rate prices relate to the overall performance scores of alternative products. The *fair-value line* on the value map is used to estimate the value of their products. This technique provides them with a fair price estimate for their offer that is consistent with their product's overall performance versus comparable products.

In the next section, we illustrate this technique using a consumer electronics case: laptop computers. Later, we describe how product line teams selling to *business* customers adapt this methodology. We show how to develop competitive value benchmarks for a product offer and to set target prices that capture added value justified by the product's competitive advantages.

CALIBRATING THE MONETARY VALUE OF PRODUCTS

Through research and consulting with global B2B clients during the last 20 years, we have developed and evolved a rigorous, repeatable, data-based process for (a) measuring the performance and (b) analyzing and assessing the value of competing products. Our goal here is to make managers aware of this methodology for overcoming the number one obstacle to implementing value-based pricing; the lack of a rigorous assessment of value. We use publicly available data from a product evaluation of laptop computers published by Consumer Reports Magazine (2008a, b). Later, we will describe a B2B client case and note some differences to bear in mind when adapting the approach to B2B markets. This methodology will be of use to anyone who manages product development, pricing or product-line marketing, as well as general managers of businesses.

Assembling the data for value assessment – the comparative performance scorecard

The first step in carrying out a customer value analysis (CVA) for value-based pricing is to define the relevant product-market category. The key questions when gathering data for a CVA are:

- What is our product? What are comparable products offered by competing vendors?
- What are the potential buyer's key purchase criteria?

- How do buying teams measure performance on the purchase criteria? Typically they use a mix of objective measures (battery life, hours) and subjective judgments (ergonomics, 1–10 score).
- What are the performance levels for our products and the alternative products?
- Which purchase criteria are most influential when buying teams assess competing offers?
- How can we calculate a measure of overall performance to balance against price?
- What is the going-rate price for each product?
- What are the market share levels and trends?

The data for a CVA are assembled and integrated into a *comparative performance scorecard*. The data for five 15-inch laptop computers, from Apple, HP, Sony, Dell and Toshiba, are shown in Table 1. Our analysis also includes five 17-inch models, which are not shown here.

The performance analysis covered 12 purchase criteria, which are named in the *attribute* column. In the *dimension* column, these attributes have been classified as being related to the product itself, to supplier services or to the company brand name. The *unit of measure* column describes how each attribute is measured. The key sources of performance measures are:

Source	*Attributes*
• Objective measures	1–5
• Customer perceptions	6, 7 (percentage of respondents satisfied with tech support)
• Expert judgment	8–12

The *better direction* column tells us whether the measure has a positive or negative relationship to overall performance. Performance data are

Table 1: Comparative performance scorecard for workhorse laptop computers (2008)

Dimension	*Attribute*	*Unit of measure*	*'Better' direction*	*Alternative suppliers*				
				Apple 15	*HP 15*	*Sony 15*	*Dell 15*	*Toshiba 15*
Product	HD memory	Gigabytes	+	250	250	250	160	160
Product	Battery life	Hours	+	4.5	3.0	2.3	3.0	1.8
Product	Weight	Pounds	−	5.3	6.1	5.7	5.9	6.5
Product	Free USB ports	#	+	2.0	3.0	3.0	3.0	4.0
Product	Screen size	Inches	+	15.0	15.0	15.0	15.0	15.0
Service	Tech support	% score	+	83	48	51	60	55
Brand	Reliability	% repaired	−	23.0	22.0	21.0	22.0	21.0
Product	Ergonomics	1–10	+	7.5	7.5	7.5	7.5	9.0
Product	Speed	1–10	+	9.0	9.0	7.5	9.0	7.5
Product	Features	1–10	+	7.5	7.5	7.5	7.5	7.5
Product	Display	1–10	+	7.5	6.0	6.0	6.0	6.0
Product	Speakers	1–10	+	6.0	6.0	4.5	3.0	4.5
Overall-performance score				7.5	6.8	6.3	6.7	6.0

Price elements	*When paid (optional)*	*Weights*	*Comparative prices*				
			Apple 15	*HP 15*	*Sony 15*	*Dell 15*	*Toshiba 15*
Price	At purchase	100	2050	1200	1470	1200	1165

listed for each product. Prices are shown in the bottom row of the scorecard. The comparative performance scorecard contains the basic data for beginning a CVA to appraise the worth of each product.

Populating a scorecard with data for value analysis and assessment

To develop a scorecard for a product line, first construct a scorecard template with a list of the key purchase criteria for assessing the products and a list of comparable products from competitors. Then assemble the performance measures. Possible data sources include objective measures of performance or customer perception ratings from a customer survey. Where such measures are not available for an attribute, the subject matter experts on a product assessment team typically reach a cross-functional consensus and assign 1–10 scores for each offer. Data on prices typically come from competitive intelligence. Data on market share levels and trends come from industry analysts. Once the key performance measures and prices are assembled into a scorecard, the information for appraising a product's value and developing product strategy has been captured – on a single page.

Once validated, the comparative performance scorecard will become a key living document for product development, product management/marketing, value-based pricing, sales and key account teams. It becomes as important to these functions as the income statement is to the finance function.

Note that the data do not have to be perfect. In a sense, the procedure used here mimics the way actual buyers evaluate the various competing products available to them. As buyers know, some data will be hard to find. It may be necessary to do some informed estimation. However, if the team is familiar with the market, it should be able to come up with a fairly accurate scorecard for the different products – one that will give a reasonably accurate and robust picture of what customers see when comparing their alternatives.

CVA provides the tools for assembling and integrating data from different sources into a comparative performance scorecard; using customer value tools to analyze the data and simulate alternative product positioning moves; and incorporating the market, customer and competitive insights gained to make better decisions about various aspects of developing successful product strategies. Figure 1 illustrates how the scorecard data and CVA tools relate to key product strategy decisions. For a write up on CVA tools and how they relate to business strategy applications (see Swire, 2010).

The key point is that once a business introduces a customer value measurement and analysis process for value-based pricing, the same data and value analysis tools can be used to better resolve a much wider range of business strategy issues. Business unit general managers can use CVA to become more market driven, customer focused and better prepared for potential competitive challenges.

Identifying performance standards and determining the importance of purchase criteria

The comparative performance scorecard is the key tool for assembling, structuring, evolving and storing successive snapshots of data for analyzing competitive shifts among offers in a category. These comprehensive data need to be processed to make it easy for business teams to grasp the monetary value of each product and the goodness of the deal it offers. To make sense of our data, we introduce additional value analysis tools (Swire, 2010).

The necessary data for further analysis is shown on the *Standards and Weights* table. This table shows, for each attribute on the scorecard, a pair of *standards*, called *basic* and *premium*. The *basic* standard represents the minimal level of performance that would be acceptable to most customers. The *premium* standard represents the level of performance that customers typically expect if they buy a premium product. These standards relate back to the continuum of

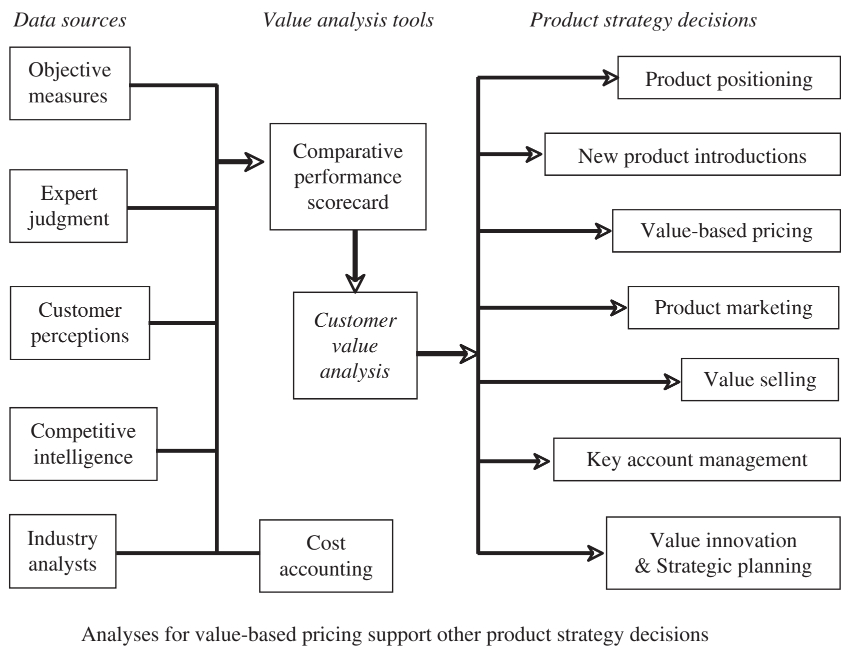

Figure 1: Flow chart for using CVA data and tools to manage customer value.

performance scores in the scorecard. As we will see, these standards will help us:

- Interpret the significance of measured performance differences from product to product.
- Assign relative-importance weights to the various attributes.

A product that performs worse than the basic standard on an attribute would be viewed as being sub-standard on that attribute. If this were a purchase criterion where a product must perform at the basic level to be considered, such a product would not make it into the consideration set of viable options for buying teams. At the other end of the spectrum, a product that performs above the premium standard would be viewed as being super premium on that attribute. If this were a criterion where buyers consider anything over the premium standard to have no added value, the team could make an adjustment in their model to reflect that the benefit to the buyers flattened out at the premium standard.

For some attributes a particular objective measure of performance may experience diminishing returns with respect to customer value. If this is the case, the analysis team can either transform the measure to be approximately linear to value in the relevant performance range. Alternatively, the team can find another measure of performance that is linear with value. For example, miles-per-gallon (MPG) is an objective measure of fuel economy that is subject to diminishing returns. Moving from 20 to 30 MPG does not save the customer as much as moving from 10 to 20 MPG. By contrast, gallons per 12 000 miles is a measure that is linear with value.

Ranking attributes based on their influence in the purchase decision

The final column in the Table 2 contains what we refer to as 'importance weights'. These weights show the relative importance of the various attributes. A project team typically assigns these weights subjectively, allocating 100 points across the various attributes. This process starts by ranking the attributes, a step

Table 2: Performance evaluation standards and weights

Attribute (measure)	*Evaluation standards*		*Relative impact of basic to premium moves*	
	Basic	*Premium*	*Rank (1 is best)*	*Weights (sum=100)*
HD memory (gigabytes)	160	250	9	5.1
Battery life (hours)	2.0	5.0	2	14.1
Weight (pounds)	8.0	5.0	3	12.8
Free USB ports (#)	2.0	5.0	12	1.3
Screen size (inches)	15	17	6	9.0
Tech support (% score)	50	80	10	3.8
Reliability (% repaired)	30	10	7	7.7
Ergonomics (1–10)	4.0	8.0	8	6.4
Speed (1–10)	4.0	8.0	1	15.4
Features (1–10)	4.0	8.0	5	10.3
Display (1–10)	4.0	8.0	4	11.5
Speakers (1–10)	4.0	8.0	11	2.6
Overall performance	4.0	8.0	—	100.0

that can be undertaken after the team has defined standards for basic and premium performance, as described above.

To rank the attributes, teams typically use the following exercise: They start by picturing a customer with a basic product, a product for which performance is at a basic level for each attribute. Then they give this imaginary customer a choice of upgrades: The customer can elect to improve performance on a single attribute from the current basic level to the premium level. Which attribute would the customer pick for the upgrade? The answer to this question reveals the highest ranked attribute. The exercise continues by having the team pick the second attribute for an upgrade, then the third and so forth. In the laptop example, the team picked speed first. Then they reviewed the data for two key purchase criteria for laptops: battery life and laptop weight. Which upgrade would they pick next? Moving battery life up from 2 to 5 hours or moving laptop weight down from 8 to 4 pounds? The team ranked battery life second and laptop weight was ranked third. The rankings of attribute importance are shown in Table 2.

Once the attributes are in rank order, the team assigns a set of weights that places more weight on the attributes ranked as being more influential. The team then proceeds to validate the relative weights with potential buyers and refines the initial set of weights to reflect customer comments.

For feedback sessions with key accounts, we suggest that teams bring along a list of the hypothesized key purchase criteria and a pie chart (not shown) of the initial set of weights. These two exhibits have proven to be good catalysts to generate additional market insights and account-specific needs. Indeed, one can take the key account buy-side team through the same process for ranking attributes by influence that one takes sell-side product marketing teams through. The discussion yields many insights for both teams and strengthens the partner relationship between the selling team and the buying team. When market research studies are available, a team can use a set of weights based on a statistical analysis of the data.

Calculating a measure of overall performance for each product

In order to assess each product's overall performance for price, which is what buying teams attempt to do, we need to construct a measure of overall performance. The first step is to calculate 1–10 performance scores for the attributes that are measured objectively (in different units like gigabytes, hours and pounds) and for the attributes that are measured as percentage scores based on customer perceptions. For example, using 4 and 8 as standards for basic and premium performance on a 10-point scale, 2 hours of battery life would score a 4, 5 hours would score 8 and 3.5 hours would score 6 on the 10-point scale. This conversion to 10-point scores also requires sign reversals for measures that are negatively related to overall performance (laptop weight and per cent repaired). Once we have a 1–10 measure where 10 means better performance, on each attribute, we can calculate a weighted average, an overall performance score for each product.

Assessing overall performance for price – the customer value map

At this point, with a measure of overall performance and a going-rate price for each of the major representative products competing in a category, we can plot the performance scores versus price on a *customer value map* (see Figure 2). The simple scatter plot of overall performance versus price is an interesting and powerful visual display. A value map enhanced with reference lines depicting the fair-value line and fair-deal zone yields still deeper insights for product positioning and value-based pricing.

The vertical line near the middle of the map represents the average overall performance level in the category. Products to the right outperform the category average. They are closer to the premium standards for key purchase criteria. Products to the left under-perform the category average. Their attribute performance scores cluster toward the basic end of the performance spectrum. The horizontal line near the middle of the value map represents the average price of products in the category. Products above this line are more expensive. Products below this line are less expensive. If a

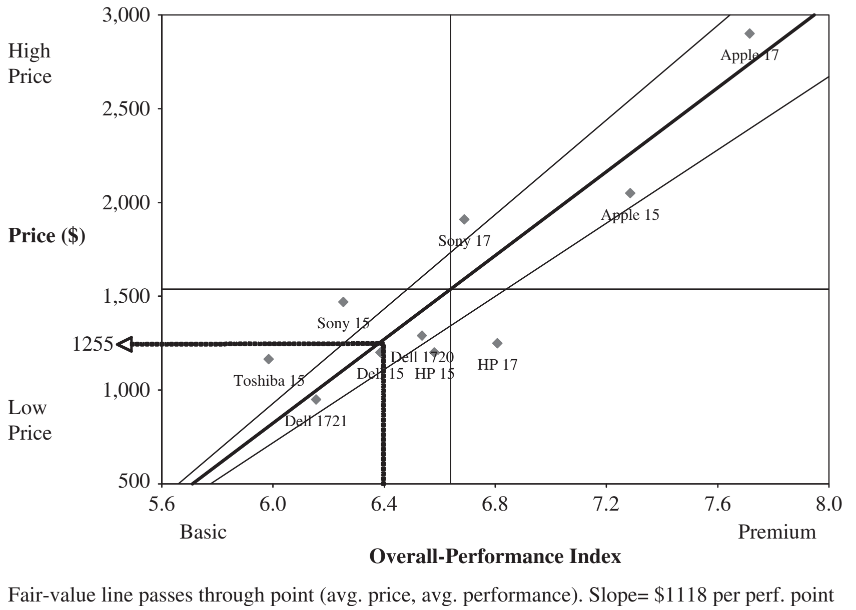

Figure 2: Customer value map for 'Workhorse' Laptop Computers, 2008.

team has sales or market share data for the products, they can enrich the value-mapping analysis by plotting bubbles that reflect the relative sizes of the competing products.

What represents a fair deal? – The fair-value line

The fair-value line is a key reference line on the customer value map. As its name implies, it is the line that represents the locus of fair-deal points on the value map. We draw the fair-value line through the intersection of average performance and average price. From a subjective standpoint, it seems fair to charge an average price for an average level of overall performance. The fair-value line slopes upward to the right, reflecting how much more customers were paying for better overall laptop performance. To position the line we need a second point in addition to the cross hairs of average price and average performance. The differences in performance drive the price differences. For the archetype buyer in the category, it seems fair for a product that is one standard deviation better in performance to command a price that is one standard deviation higher in price. This provides the second point for drawing the fair-value line.

Which offers represent the best or worst deals? – The fair-deal corridor

The fair price for a product is a point estimate. To visualize a range around this point estimate we introduced the concept of a fair-deal zone, flanking the fair-value line. The fair-deal zone is set statistically, based on the distribution of a relative competitive value metric, which we describe in the next section. Roughly, one-quarter of the offers in a value analysis plot above/left of the corridor and one-quarter plot below/right. Half tend to fall within the fair-deal zone. With the fair-deal zone as a reference, a team can quickly see which of the products are in the worst or best quartiles of the offers in terms of delivering relative competitive value to customers. Products above the fair-value zone would appear to customers as overpriced. They often end up losing market share. Products below the fair-value zone are bargains. They often gain market share.

A business unit general manager and the product line leaders can check to see whether the market share levels and trends are consistent with the product positions on the value map. This may yield further insights for refining the expert judgment scores and/or relative importance weights. The evolving scorecard data are often validated and updated with input from potential buyers. Techniques for doing this include customer interviews, customer listening sessions with cross-functional buying teams, quantitative focus groups with customer buying teams, and market research surveys.

What is the monetary value of each product? – Customer value metrics

The slope of the fair-value line for this snapshot of workhorse laptops is a little more than US$1100 per point of overall performance. This means that if a product, like the Toshiba 15 with an overall performance score of 6.0 could improve its performance by one point (on the 10-point scale) on every attribute, it would be worth $1100 more.

How much is each product worth – relative to competing offers? To gauge how much a product is worth, we can position its overall performance score on the horizontal axis of the value map, go up to the fair-value line, and then over to the price axis. For the Dell 15 model, the fair price, or competitive benchmark of its value to customers versus other workhorse laptops is $1255. Based on the fair-value line and overall performance scores we can calculate a monetary value of how much each product is worth, see Table 3.

Table 3 shows five customer value metrics for each of the laptop models in this snapshot. The overall performance scores are calculated as a weighted average of the scores on the key purchase criteria. The prices are going-rates, or street prices, which were assembled in the comparative performance scorecard. The fair price for each model depends on its overall

Table 3: Customer value metrics: Workhorse Laptop Computers (2008)

Customer value concept	*Unit of measure*	*Apple 15*	*HP 15*	*Sony 15*	*Dell 15*	*Toshiba 15*	*Apple 17*	*Sony 17*	*Dell 1720*	*HP 17*	*Dell 1721*	*Average*
Overall performance score	1–10	7.3	6.6	6.3	6.4	6.0	7.7	6.7	6.5	6.8	6.2	6.6
Price	$	2050	1200	1470	1200	1165	2900	1910	1290	1250	950	1539
Fair price (monetary value)	$	2261	1473	1106	1255	807	2741	1594	1423	1726	998	1539
Customer surplus	$	211	273	−364	55	−358	−159	−316	−133	476	48	0
Relative competitive value	%	9	19	−33	4	−44	−6	−20	9	28	5	0

performance score and the fair-value line, which captures the relationship between overall performance scores and warranted prices of products in the category. Customer surplus is calculated as fair price minus price. It is a monetary measure of the goodness of the deal that each offer delivers to customers. Relative competitive value is another measure of customer surplus, expressed as a percentage of the fair price. Models with high relative value are positioned to gain market share. Models with low relative value are likely to lose market share.

STRATEGIC PRICING – BASED ON VALUE BENCHMARKS

The fair-value line and zone on a value map are based on (a) *going rate prices* and (b) *overall performance scores*. The fair price for a product is a competitive benchmark for the *value* of the product. Targeting a price close to the product's fair price, like the Dell 1721 model in this snapshot, is a neutral pricing strategy. Products priced below the fair-value line are positioned to buy market share. Products priced above the fair-value line are positioned to boost short-term margins, possibly at the cost of market share loss.

In this time period, it looks like HP was pricing to gain market share, thereby putting pressure on other laptop makers. The HP models had the highest relative competitive value scores: The price of an HP17 was 28 per cent below the estimated fair price for that product; the HP15 was priced 19 per cent below its benchmark. When reviewing this laptop case, product strategists and pricing specialists like to discuss whether HP was unknowingly leaving money on the table or consciously pricing below fair value to gain share in the laptop category in 2008.

The value map and value metrics suggest that Sony was pricing for margin. But, the *Consumer Reports* product evaluation does not take intangible, image-related factors into account. Perhaps the inclusion of brand-image factors, which do affect buying decisions, would reposition the Sony models to be more competitive. Discussing products positioned outside the fair-value corridor and their market share movements can help a team to refine its initial value scorecard to be more consistent with observed trends in each product's sales.

ASSESSING THE VALUE OF PRODUCTS SOLD TO BUSINESS CUSTOMERS

In the *Consumer Reports* evaluation of laptops, most of the non-price purchase criteria are related to the performance of the product itself. There are 10 product attributes, one service attribute and one attribute that relates to repairs for the *brand*, rather than to an individual model. In business markets, buying teams assess not only attributes related to the product, but also attributes related to supplier services, the customer–supplier relationship and supplier reputation. The buyer simultaneously chooses a *product* and a *supplier*, as we will illustrate in the next section.

Value assessment of a commercial equipment product – case synopsis

Commercial equipment vendors typically identify three customer types that influence purchasing decisions – specifying engineers, building owners and the contractors who install the equipment. The importance weights on the purchase criteria differ across benefit segments. In the segment where specifying engineers are highly influential, product attributes carry more weight. By contrast, building owners tend to place more emphasis on attributes impacting the total cost of ownership. Contractors place more weight on supplier services. They do not want the product delivered too early because it might be damaged or stolen while waiting to be installed. They do not want it delivered late because that would reduce the productivity of their installation teams and could subject their business to late-completion penalties.

This example focuses on the market segment where contractors have the heaviest influence on which product/supplier is selected. The segments dominated by *specifying engineers* and *building owners* were analyzed separately and are not shown here. In the *contractor segment*, five of the attributes relate to suppliers and only two focus on the product itself (Table 4).

This team decided to assess three of their models, designated *A1*, *A2* and *A3*, against the product lines of three competitors. A1 was their top-of-the-line product, A2 was their mainstream product and A3 was a\their basic, no-frills product. The team's panel of industry experts supplied the initial subjective performance scores on a 1–10 scale. The team refined these scores based on feedback from customers. The value map in Figure 3 displays 10 products offered by the four leading suppliers (Figure 3).

When the team reviewed the value map they found that their best and better products (A1 and A2) were priced within the fair-value

Table 4: Performance dimensions and benefit attributes for a commercial equipment product

Dimension	*Attribute*
Product	Performance
Product	Footprint
Supplier service	Lead-time
Supplier service	Ease of doing business
Supplier service	Ease of installing
Supplier service	Warranty
Supplier–customer relationship	Delivery timing

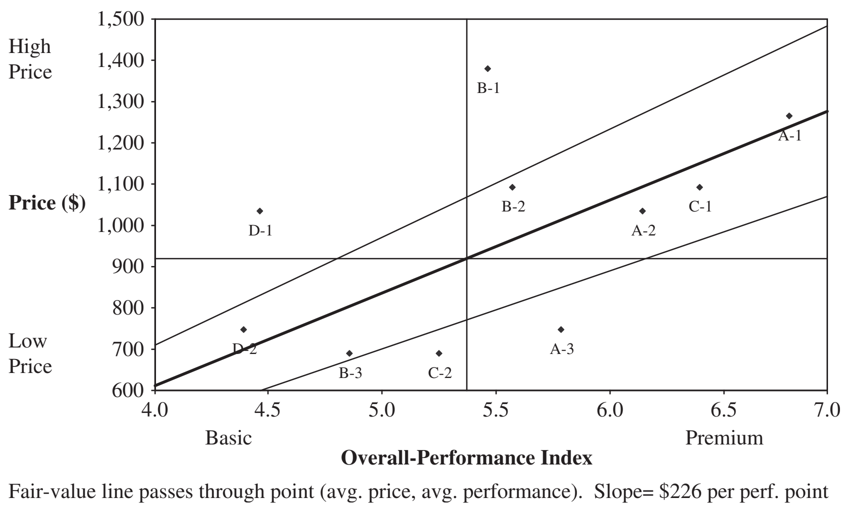

Figure 3: Customer value map for business equipment – Contractor segment.

corridor, and quite close to the fair-value line. Their basic product, however, A3, seemed to be under priced. The team identified C2 as their product's closest competitor and proceeded to review attribute-level scores head-to-head. The scores for product performance and footprint were the same. There were service advantages on lead-time, ease-of-installation and delivery timing. These service advantages had not been considered by the product development and pricing team at launch. They came into play, however, once the product was on the market. On the basis of their value analysis, the team took several actions to achieve higher pocket prices and overall business results. The case can be summarized as follows:

Business situation: New product development (NPD) and pricing teams had missed key service advantages when targeting a price for the A3 product

Insights gained from competitive value assessment:

- Value map: suggested we are leaving money on the table for product A3.
- Comparative performance scorecard – we have vendor service advantages versus the closest competing product.

Actions taken by product management team:

- Emphasized superior logistics services and ease of installation in marketing campaigns and sales collateral targeted at the contractor-influenced segment.
- Raised list price a small amount.
- Tightened up on discounts, especially in deals where the contractor plays a key role in selecting the vendor. Began to enforce a policy that was already in place but had not been enforced: Do not give additional discretionary discounts when contractors specify delivery windows that are tighter than normal.

Results achieved:

- Higher pocket prices in the service sensitive segment.
- Higher margins and profits.
- Held market share.

Key to project success: Having the value assessment team look beyond technical product criteria to include a full range of supplier service attributes.

For more information on applying CVA in business markets see Gale (2011). This video presentation contains: (a) case vignettes highlighting the business issue, analysis steps, insights gained, actions taken and results achieved, (b) responses to frequently asked questions, (c) examples of how segmentation and differentiation link to value analysis, and (d) steps for getting started.

INSTALLING A CUSTOMER VALUE MANAGEMENT SYSTEM

When targeting a particular price-for-performance position against competing products, NPD teams tend to focus on benefit attributes that relate to the product itself. They compare how well their new product will perform at launch versus established products. Sometimes forgotten is the fact that comparative performance on the supplier services, customer–supplier relationship, and reputation dimensions of value will also affect the realized price and sales volume of a new product. There can be a disconnect as a product passes from product development into the product management phase of the life cycle. An NPD process focused on just *product* attributes and targeted prices but not on how *customers assess suppliers* is incomplete. This disconnect, between the product development and marketing views, is a key problem for business unit general mangers.

A second issue for business heads, as we have discussed in this article, is that their teams do not have the tools to calibrate the monetary value of their products. Competitive analyses by NPD or line-of-business teams usually do contain some insights from voice-of-the-customer research. These analyses stop short, however, of constructing competitive, performance-based benchmarks of how much a product is really worth. In fact, our observation is that most companies do not have a rigorous process for measuring the overall performance and value of their products – either in the product development phase or in the product management phase.

Most companies would benefit greatly by installing a customer value measurement, analysis and *product appraisal process*. Such systems track comparative supplier and product performance through the development, launch and product management phases of the product life cycle. Introducing a customer value management system would help business unit general managers better align their NPD and line of business teams. It would make their organizations more market driven, customer focused, competitor savvy, effective and profitable.

CONCLUSIONS

The value-mapping approach described here is similar to the approach that real estate appraisers take when they estimate the market value of a house (see Brueggeman and Fisher, 2005, pp 188–193). They begin with the selling prices of comparable properties that have sold recently as an initial set of value benchmarks. They then adjust these benchmarks up or down systematically, depending on how the lot size, house size, quality and so on differ from the subject property. Professionals responsible for setting the appraisals that towns use for tax bills develop algorithms that receive the characteristics of a property as input and put out an appraised value. In our value-mapping framework, the fair-value line and corridor are based on both *going-rate prices* and *composite overall performance scores* of the key competing products as inputs. Prices are set strategically *based on a value benchmark* associated with a product's performance level – in the context of a visual display of the competitive landscape in a market category.

In recent years, new techniques and tools have been developed to enrich the value-mapping process. Scale transformations enable engineers to measure and simulate changes in attribute level performance using objective measures on different scales for some purchase criteria and subjective 1–10 scores on others. The flexibility of being able to use the same objective measures that they use in designing products is an attractive feature for NPD teams. Product managers appreciate the option of graphing a line depicting the cost per unit for their product on the value map. This enables them to see their product's worth-to-cost ratio and profit margin, in addition to their relative value to the customer. Product planners and sales teams appreciate the *product appraisal table* (Gale and Swire, 2006; Swire, 2010), which displays the worth differences between a subject product and a competing product head-to-head at the attribute level. Strategic pricing teams like the capability to superimpose the performance level and target price for a new product onto a value map based on the incumbent products that it would face at launch. This helps them to gauge the potential competitiveness of their new product and whether its price is targeted as too high, or too low, based on its overall performance versus incumbent products. Finally, business unit general managers that are attempting to make their business a preferred supplier in the customer's eyes appreciate the ability to include supplier attributes as well as product attributes when readying a new product for launch.

Once a business team completes a value-mapping analysis, they will know a lot more about the competitive product strategies and the key strengths and weaknesses of all the products competing in the targeted market. Moreover, they will be on the way to shifting toward pricing based on going-rate prices and a *comprehensive appraisal based on competitors' performance scores on key purchase criteria*. They will be on the way to developing successful value-based product development, management and marketing strategies. They will begin building an appraisal process for measuring value and targeting the right price levels for their offers.

NOTE

1 The idea of scatter plots as an analytical tool goes way back. The *price–performance* curve, which plots prices versus a specific aspect of product performance (for example, expected miles per tire), has been a staple of technology analysis for a long time. The use of a value map (price versus a *composite* index of performance) for assessing the competitive landscape, product positioning and strategic pricing – was introduced in book format in *Managing Customer Value*. The value map concept has been further developed by Marn *et al* (2004) and discussed by other authors of pricing books, see Dolan and Simon (1996), Nagel *et al* (2006).

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Research Article

Aligning the pricing organization to the market type in industrial markets

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Tim J. Smith
DePaul University, USA

Tim J. Smith is Managing Principal, Wiglaf Pricing and Adjunct Professor of Marketing & Economics at DePaul University (USA).

Correspondence: Tim J. Smith, Managing Principal, Wiglaf Pricing, Adjunct Professor of Marketing & Economics, DePaul University, USA.
E-mail: tsmith@wiglafpricing.com

ABSTRACT Not all industrial markets are alike, and therefore the pricing organizations within firms serving industrial markets are also dissimilar. In this article, we will examine the alignment of the firm's organizational structure, routines and tools used in pricing in relation to the market type. The analysis will be based on aligning the core pricing challenges facing the firm to the transactional landscape, where the transactional landscape is defined by the value and volume of transactions. Market types in the transactional landscape can be characterized as a niche opportunity (mouse), a high-value/low-volume transaction market (hawk), or a low-value/high-volume transaction market (seagull).

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INTRODUCTION

Just as form follows function in architecture, we should expect the firm's pricing organization strategy to be informed by the nature and frequency of the pricing challenges faced by the firm. In this article, we will map the characteristics of the nature of the pricing challenges faced by firms in industrial markets into a prescriptive organization design template. To aid executives in classifying their pricing challenges, we use the transaction volume and value map to classify market types by their addressable market opportunity.

THE TRANSACTION VALUE AND VOLUME MAP

The transaction volume and value map classifies firms according to their addressable market opportunities (Smith, The Transaction Landscape, 2006). On the horizontal axis we identify addressable markets by the value of a customer's purchase decision. On the vertical axis we identify addressable markets by the volume of customer purchase decisions.

We define addressable markets as those a firm can meaningfully expect to serve within the next period of strategic engagement, typically a year to 3 years. We define a transaction as a customer purchase decision. The focus is placed on transactions rather than units because transactions are the key customer interactions, which a firm must influence in order to successfully compete within their market.

The efficient and effective techniques used for managing a single large transaction involving many units is very different from those techniques used for managing multiple small transactions of fewer units. For instance, the sales process associated with selling a million automatic meter reading devices to a single water utility company is very different from that engaged in selling the same million automatic meter reading devices to thousands of residential apartment owners a few units at a time for water submetering.

For the sake of identifying a firm within the transaction volume and value map, if the customer treats each purchase as a separate decision, these purchases should be identified as separate transactions. If the customer treats several purchases as a single decision, even if these purchases are non-concurrent, these purchases should be identified as a single transaction. Thus, a single purchase decision may involve the purchase of a single item or many items, but will occur at a single point in time even if the purchases occur over time.

This choice of defining transactions according to purchase decisions, and therefore according to the customer's behavior, is in line with the sales methodologies practiced within many firms across many industries. For instance, Herman and Sanchez defines sales opportunities according to single sales objectives in individual selling cycles (Heiman and Sanchez, 1998). Similarly, Rackham focuses the sales process around identifying specific problems and the implications of those problems that a given solution can address (Rackham, 1988).

Within the transaction volume and value map, we loosely define three areas to conceptually classify addressable market opportunities for industrial firms. These are the hawks, seagulls and mice markets. Seagull markets are characterized as having many low-value transactions. Hawk markets are characterized as having few high-value transactions. Markets with few transactions each of relatively low value are be characterized as mouse markets. Beyond some frontier of transaction volume and value, no market exists (see Figure 1).

Managers attempting to identify their addressable market as a hawk, seagull or mouse market might find it easier to consider how they address their customers. If their market has many customers and they focus mostly upon transactional selling, perhaps through call centers, websites or other forms that involve frequent but brief interactions with many customers purchasing low-value items, they may consider themselves as serving seagull markets. If their market has fewer customers and they focus mostly upon consultative selling with a direct sales force negotiating individually large transactions over a longer period of time, they may consider themselves as serving hawk markets. If their market is somewhat smaller, they may consider themselves as serving a mouse market. The strategies firms addressing mouse markets use alter between those found in hawk or seagull markets according to management discretion and resource constraints.

We offer the classification of market types by transaction volumes and values as an alternative to typical industrial market classifications according to products, customer groups, units sold or revenue in the belief that this classification structure will enable greater clarity in guiding organizational design considerations across industries. Classification by product alone would lead to challenges similar to that mentioned of grouping both infrequent but large sales of meters to utilities and frequent but small sales of submeters to apartment owners into a single category although they have highly dissimilar sales and pricing challenges. Similarly, classification by customer groups would place coal suppliers in the same group as maintenance, repair and operations suppliers to utilities, which again face highly dissimilar sales and pricing challenges. Similar challenges are faced when classifying firms by units alone or revenue alone for identifying the sales and pricing challenges of a firm. As the sales and marketing challenges are somewhat similar among firms with similar transaction volumes and value, we believe this approach is more appropriate for guiding organizational design decisions and comparisons across firms.

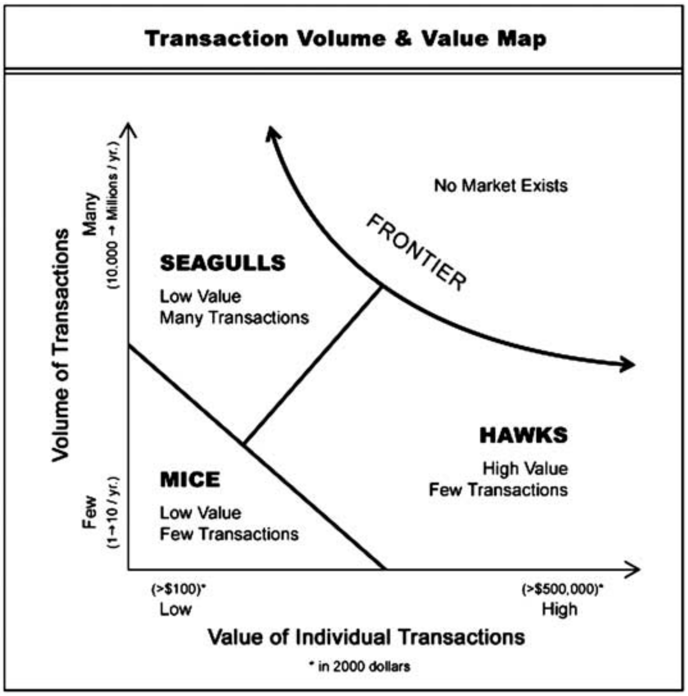

Figure 1: A conceptual map of the addressable market types within the transactional volume and value map.

PRICING DECISIONS

Schindehutte and Morris classified pricing decisions as pricing objective, price setting, discounting, price structure and pricing strategy (Schindehutte and Morris, 2001; Smith, 2012). With respect to designing a pricing organization, the most frequent challenges addressed regards those of price setting, discounting and structures.

- *Price setting* refers to establishing the go-to-market prices for individual products and services.
- *Discounting* refers to the situational use of price variances for specific customers, market segments or sales opportunities.
- *Price structure* refers to the architecture around which the firm's price mix is designed. For example, individual unit pricing, two-part tariffs, tying arrangements, versioning, bundling, subscriptions and yield management each forms the basis for defining different price structures.

Price setting, discounting and structuring decisions occur at varying frequencies and have varying impacts on the profitability of the firm. Discounting decisions, because of their tactical nature, are typically higher frequency decisions than setting and structuring decisions. Individual discounting decisions generally have little impact on the firm though their cumulative effect can be great. Price setting decisions generally occur more frequently than discounting decisions and less frequently than price structure decisions. Similarly, price changes generally have a larger impact on profitability than individual discounting decisions yet smaller impact than changes in price structures. Changes in price structures are generally rare, often reflecting a strategic change of the firm. As such, they are generally the least frequent but potentially hold the largest impact on the profitability of the firm.

Price setting, discounting and structuring decisions benefit from differing analytical approaches. And within each class of pricing decisions, marketers have developed a variety of techniques to facilitate rational decision making.

It has been observed that firms addressing seagull versus hawk markets face pricing decisions with different informational resources. Price transparency, ability to meaningfully conduct survey-based market research, and ability to meaningfully track and compare contemporaneous offers found in many seagull markets is mostly absent in hawk markets. These differences in informational resources drive a difference in the techniques used to address pricing decisions.

Because form should follow function, we would logically expect that the proper organizational structure and responsibilities would be influenced by the type and frequency of pricing decisions that it will manage and the techniques it will use to manage those decisions. Therefore, the organizational design for firms serving seagull markets will necessarily differ from that serving hawk markets.

SEAGULL MARKETS

Seagull markets are characterized as having relatively many low-value transactions. Examples of firms in these markets include medical, office, fastener, molded plastics, desktop computing, payroll management and maintenance-repair-and-operations suppliers to name but a few. Although some of the products sold by firms in seagull markets might define new product categories, a majority of transactions will focus on mature to maturing product categories. Because the product categories are observed to be relatively mature in most seagull markets, it is reasonable to expect customers in these markets to be relatively well informed of the different products within a specific category enabling them to make reasonable decisions regarding the value of different features and benefits. These market characteristics will influence the structure, routines and tools necessary for managing pricing challenges.

PRICE SETTING IN SEAGULL MARKETS

Seagull markets by definition have many customers. As in all markets, different customers will exhibit different willingness-to-pay. Because the markets are large, and because customer's willingness-to-pay varies, market research approaches that rely on survey techniques have generally been found to be cost-effective and appropriate for detecting the value of an offer as perceived by the market, as well as the variation in the value customers place on an offering. (When the addressable market for a product is insufficiently large to warrant the investment in market research, executives may want to consider that product to be addressing a mouse market and refer to the approaches listed therein.) Through analytical techniques, market researchers are able to convert this information into estimates of the demand curve, and therefore identify the appropriate go-to-market price.

Conjoint analysis has dominated the various techniques utilized by marketing researchers trying to identify list prices from consumer survey data (Green *et al*, 2001). Other techniques, such as the use of open ended questions ('How much would you be willing to pay for this item?') or Van Westerndorp Price Sensitivity Meters, have been found to suffer from various flaws originating from bargaining behavior of survey respondents or insufficient precision for tendering a decision.

Conducting market surveys in general and conjoint analysis specifically requires specialized skill sets. As list prices are generally updated infrequently and because the skills required to execute a sound survey and conjoint analysis are not widespread, it is observed that most firms choose to outsource specific market research efforts in price setting rather than building that organizational strength internally. Even though additional organization structure is rarely developed to specifically address price setting challenges, firms generally benefit from leveraging resources in product management to interface with external support conducting the market survey.

DISCOUNT MANAGEMENT IN SEAGULL MARKETS

With many customers holding a variety of maximal price points they are willing-to-pay, firms addressing seagull markets can often improve their profitability through disciplined discounting. The word 'can' is the key in the above sentence. Discounting with discipline is no small feat. It implies segmentation hedges that guide a firm's discounts can be properly constructed in a manner that encourages customers willing-to-pay higher prices to neglect the discount while capturing those customers willing-to-pay only lesser prices through the engineered discount. When these segmentation hedges cannot be constructed to discourage customers with a higher willingness-to-pay from buying at the discounted price, discounting ceases to be a discount from the set price and instead becomes a new lower, normal price paid by customers. This new, lower price is generally less profitable than that determined through rigorous price setting techniques.

In seagull markets, firms engage many customers in relatively contemporaneous transactions where the firm's attempt at favorably influencing the customer's buying decision may involve a discounting decision. The high frequency of discounting decisions implies that firms can profitably benefit from developing an organization capability for managing these decisions.

The purpose of an organizational capability for managing discount decisions is to convert tacit knowledge into explicit knowledge resulting in a reduction of decision errors. Discount decisions originate from customer interactions with salespeople. These salespeople hold beliefs regarding their customers' willingness-to-pay that are informed through their direct interactions, and the reasons for granting discounts on specific transactions are often difficult to fully express and more difficult to validate. For instance, discounts granted for reasons of 'to meet the competition' are strongly influenced by the individual salesperson listening to customer comments and that salesperson's ability to detect whether the discount is necessary for capturing that specific transaction. By developing routines and applying analytical techniques, it has been observed that firms can uncover patterns that explicitly reveal when discounts can be profitably used to influence customer behavior, and when they may be unnecessary.

Discount management, as an organizational capability, implies the firm is able to monitor discount decisions, analyze the effectiveness of discounting decisions and develop routines for managing future discounting decisions. This implies the development of a pricing organization within the firm to manage the routines and conduct the necessary analysis.

Monitoring of past discount decisions often relies upon standardized studies of transactional data through price waterfalls, net price bands and price variances by market segment. (Marn and Rosiello, Managing Price, Gaining Profit, 1992) (Geisman and Maruskin, 2006) These studies may be automated through the use of specialized information systems for frequent monitoring or they may be done periodically through labor-intensive analysis of transaction level data using standard office technology.

Guiding future discount decisions often comes in the form of a quantitative profit impact analysis, criteria-based discounting, incentive alignments through profit-based compensation components or escalation policies to address decisions that merit further expertise.

Firms do not necessarily benefit from all of these approaches to guiding discount decisions simultaneously, but rather executives can make tradeoffs between the above four approaches to guiding discounting decisions. For instance, when discounting decisions have been fully routinized, perhaps through profit impact analyses or other criteria-based discounting policies, salespeople will have little to no influence over transactional discounting decisions.

When salespeople have no influence over discounting decisions, profit-based compensation components will have insignificant positive influence and potentially significant negative influence as salespeople will have no control over the profit of a transaction, only the number of transactions, and may not understand how their efforts result in compensation. In these cases, revenue or even volume-based incentives may prove to serve as a clearer performance incentive. However, where managers have latitude in making discounting decisions, perhaps owing to having a higher level of responsibility over a number of salespeople or by granting individual salespeople some discretion over discounting, profit-based commissions have been observed to deliver greater better discounting decisions because they align the individual manager's incentives to the profit goals of the firm.

PRICE STRUCTURES IN SEAGULL MARKETS

While the entire gamut of price structures can be found in seagull markets, the attribute of having a large number of customers engaging in frequent transactions influences price structures decisions. Specifically, price structures tend to be more explicit in seagull markets, perhaps through the publication of catalogues or automated price configurators.

Explicit price structures coupled with explicit product benefit and differentiation communications enable the firm to facilitate customer self-selection of value sought. Buying decisions require customers to make tradeoffs between benefits received and price paid. When customers can easily understand the tradeoffs and manage the buying decision process with little sales involvement, sales efficiency can be enhanced. Because seagull markets are characterized by high-volume and low-value transactions, firms operating in these markets generally benefit from reducing expensive one-on-one sales efforts by leveraging broader marketing communication efforts.

HAWK MARKETS

Hawk markets are characterized as having relatively few high-value transactions. Examples of firms in these markets might include commercial aircraft manufactures, power plant developers, enterprise software suppliers and silicon processor suppliers to name but a few. Most of the offerings sold into hawk markets are highly complex with many sources of benefits for customers. Moreover, transactions in these markets are, by definition, few and infrequent. These characteristics drive firms serving hawk markets to utilize different techniques for managing price setting, discounting and structures from those serving other markets, and therefore the organizational requirements for firms addressing hawk markets are distinct from those addressing other markets.

PRICE SETTING IN HAWK MARKETS

The key factors that drive price setting in hawk markets to leverage different tools and techniques than those used in other markets are the infrequency of purchase and the product's complexity.

With infrequently purchased goods, the average potential customer generally does not possess accurate information regarding the competing products, their benefits and their prices. Thus, survey techniques that seek to gain information from these uninformed customers are flawed in design. Correcting these flaws may imply seeking to survey only customers that are currently in the market. However, the few customers that are currently in the market are, by definition of being in a hawk market, a handful out of a few handfuls of potential customers. Therefore, it is difficult to definitively claim that a sample handful of customers that happen to be currently in the market are representative of all customers that will be in the market, or that the prices appropriate for 1 year can be carried over into the next year. In place of survey techniques, market research based on in-depth customer interviews, perhaps using Voice-of-Customer approaches, have been demonstrated to reveal more accurate and relevant information regarding the value customers place on competing products and their options.

Moreover, with highly complex products, the average potential customer may not know the value differences they would place on competing products, much less the value they would place on the options associated with specific products, unless they are confronting a purchase decision. In order to uncover the value differences between products or configurations of products, many customers in hawk markets conduct a complex financial analysis of the product value over its useful lifetime. Firms attempting to sell into hawk markets can utilize this exact same technique to identify go-to-market prices.

Exchange value models quantify the value of a product by comparing it to its nearest competing alternative (Dolan, 1999; Marn *et al*, Introduction, 2004; Smith and Nagle, 2005a, b). For each competing alternative, the pricing professional will itemize the significant differences in attributes, features and benefits; then derive an economic model of the financial impact of those differences. By adding up the price of the nearest competing alternative to the financial impact of the positive and negative differentiating factors, the economic exchange value of the product can be identified. From an economic perspective, any price set at or below the economic exchange value should encourage customers to purchase. Executives often set prices below the identified economic exchange value because they do not expect all customers to fully value all aspects of the product, or they do not believe the firm can capture the full value of the benefits delivered by the product while simultaneously capturing customers.

In-depth customer executive interviews leading to the construction of exchange value models has proven to many firms to be an efficient and effective means to identify effective go-to-market prices (Holden and Burton, 2008).

From an organizational perspective, both the in-depth customer executive interview and the construction of exchange value models are processes that a firm can either outsource completely, outsource partially or insource completely. The choice of who executes this effort, in-house resources external resources, or a combination of both, is largely driven by tradeoffs between the frequency of the need and the cost of maintaining the specialized resources required for execution. However, the decision to execute this approach is generally beneficial to all firms addressing hawk markets. As such, price setting challenges may involve routines for identifying the right team, *ad-hoc* or within an existing structure, for addressing the decision challenge.

DISCOUNT MANAGEMENT IN HAWK MARKETS

The infrequency of transactions in hawk markets implies that discount decisions are infrequent, and therefore require a different managerial approach than in other business markets.

A clear understanding of proper discounting rules can be difficult to develop for firms serving hawk markets for two main reasons. One, because few transactions occur in the same time frame, and the situations of the customers will vary greatly between the transactions, analytical techniques that rely upon statistical analysis across transactions are subject to many biases and outlier effects, leaving many managers dubious of their informational value. Two, the managers holding the most tacit knowledge of the proclivity of the customer to purchase, the salespeople, also hold a bias towards ensuring the successful close of the sale. Owing to these factors, an adequate and standard set of quantitative routines for monitoring performance of past discounting and guiding decisions regarding future discounts has not been developed for this type of markets, and very few firms in hawk markets have developed their own customized routines as well.

Instead of routine quantitative analysis of past discounts and guidance for future discounting decisions in the form of rules, firms addressing hawk markets often turn to incentive alignments and decision escalation routines coupled with a quantitative profit impact analysis. Much of the knowledge required for guiding discounting decisions remains tacit knowledge, held and developed by direct managerial experience with negotiations between the customer and the company. Utilizing this tacit knowledge through rules, which require increasing discounts to be approved by increasing levels of authority and experience, enables the firm to bring an appropriate level of scrutiny to varying transactions. This escalation policy is further enhanced through aligning salespeople's incentives to the firm's profit incentive through profit-based compensation components.

PRICE STRUCTURES IN HAWK MARKETS

With high-value complex products, a large number of factors are likely to drive variations in the benefits customers receive from different features, and therefore differences in the willingness-to-pay of customers and differences in the appropriate price for different transactions. These factors will be sensitive to the customer's situation and the customer's purpose for the product. Price structures defined through these factors and their influences on situation-specific valuations are useful for setting transactional prices. Owing to the numerous factors influencing offering valuations by customers according to application or situation, price structures in hawk markets are likely to be highly complex.

Because each transaction is managed directly in hawk markets, price structures do not have to be simplified for mass communication. Furthermore, for some products and services sold to hawk markets, customers will be sufficiently convinced to purchase the product as long as the value they come to understand to be delivered through the transaction is in excess of the total transaction price as determined by the price structure after comparing the product to its competing alternatives. As such, it has been my direct experience that the full price structure used for calculating transaction prices does not always need to be communicated with customers for securing the transaction in hawk markets, only the total transaction price is necessary in some situations.

MOUSE MARKETS

Firms addressing mouse markets are usually resource constrained. This resource constraint reduces the ability of firms to address pricing questions through the development of dedicated organizational resources. However, by leveraging targeted outside support with management insight, firms operating addressing mouse markets can still find substantial value in improving pricing practices.

For instance, instead of conducting a formal market research effort using customer surveys or executive interviews, executives in mouse markets can leverage their own insight into customer decisions to construct an exchange value model, either alone or with targeted support. From these internally constructed exchange value models, prices can be set that are significantly better than those set in accordance with cost-plus rules or pricing-under-the-competition-based biases (Smith, 2005).

Similarly, with respect to discount monitoring and management, executives in mouse markets benefit from conducting periodic reviews of past customer engagements and transactions coupled with discussions with direct executive involvement in discounting decisions. While these internal reviews of discounting decisions may not develop into formal quantitative analysis, the review of past decisions and outcomes alone is likely to uncover errors and correct decision making biases.

Table 1: Variation of dominant pricing techniques and organizational requirements according to addressable market type

	Hawk	*Seagull*	*Mouse*
Addressable market characteristics	Few high-value transactions.	Many low-value transactions.	Few low-value transactions.
Price setting			
Technique	In-depth customer executive interviews followed by the construction of an exchange value model.	Conjoint or other market survey approaches.	Firm's executives develop an exchange value model, potentially with outside support.
Organizational requirements	In-sourced or out-sourced depending on frequency and cost of maintaining specialized skills. Development of routines for managing the process.	Generally outsourced effort with existing staff interacting with external expertise.	Resource constraints limit organizational development.
Discounting			
Technique	Decision escalation coupled with managerial incentive alignment to the firm's profit motive.	Monitoring through transactional data analysis. Management through formalized routines and techniques.	Periodic review of transactions and discount decision for enhancing executive learning.
Organizational requirements	Increased demand for participation in discounting decisions by sales executive structure.	Strong organizational requirements for decision monitoring and management.	Resource constraints limit organizational development.
Price structure	Complex price structures, not necessarily revealed to customers.	Explicit price communication facilitates reduced selling costs.	Varies

DISCUSSION

As argued, the transaction landscape provides a guide for designing the pricing organization within firms competing in business markets. The suggestions of this article are summarized in Table 1.

Much research has yet to be done on this paradigm. While most market research textbooks, sales technique textbooks and pricing books would support the suggestions of this article, and many would conclude that the suggestions of this article are intuitively obvious, there has been scant cross-industry research to indicate that these suggestions are widely deployed or research to indicate that the hawks, seagulls, mouse paradigm accurately depicts the variation in challenges faced by firms in business markets.

Rather than proving the suggestions contained herein, the purpose of this article is to enable executives to identify the appropriate template organizational structure, routines and tools for managing pricing decisions. From this template, it is expected that many variations will be observed and profitably enhance the firms using the techniques and organizational enhancements mentioned herein.

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Research Article

Pricing practices and value creation logics

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Magnus Johansson and Linn Andersson

Lund University, Lund, Sweden

Magnus Johansson holds a PhD from the School of Economics and Management, Lund University and has worked with strategic analysis and planning within the IT, telecom, automotive and general industry. His research is focused on value creation and pricing strategies in business-to-business firms.

Linn Andersson is a PhD candidate at the Institute of Economic Research at Lund University, Sweden. Her research addresses pricing capability in the context of business-to-business relations, with a focus on multinational, manufacturing firms acting in mature industries.

Correspondence: Magnus Johansson, Department of Business Administration, School of Economics and Management, Lund University, PO Box 7080, 220 07 Lund, Sweden
E-mail: a.magnus.johansson@gmail.com

ABSTRACT The pricing literature is mainly concerned with pricing in association with standardized products and services. This article addresses the topic of pricing from the perspective of value creation logics, focusing on highly customized deliveries rather than standardized products. The article first outlines a framework of pricing settings, depending on value creation logics. It then exemes parts of this framework through an empirical illustration of pricing practices within an industrial firm supplying highly customized deliveries. In particular, the article identifies the appropriateness of applying economic versus customer value pricing practices depending on the value creation setting.

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INTRODUCTION

Much of today's pricing and customer value research is concerned with the pricing of generic offerings, products as well as services, and therefore adhere primarily to the generic product or service value creation process (for example, Bernstein and Macias, 2002; Smith and Nagle, 2005; Hinterhuber, 2008b). Similarly, Dutta *et al*'s (2003) outline of pricing processes depends largely on generic product offerings. Nagle and Hogan (2006) follow an analogous logic in their discussion of how value should be captured after establishing products or services that fit pre-identified segments. In other words, the pricing process is closely linked to the product planning process.

However, the distinction Dutta *et al* (2003) make between pricing processes 'within the firm' and pricing processes 'vis-à-vis customers' indicates a difference in pricing activities depending on the character of customer interaction. In addition, Hinterhuber (2008b) states the importance of recognizing consultative aspects that create value in relation to pricing.

One way of framing the differences between consultative, customer-close value creation and generic product or service value creation is by applying the concept of value creation logics (Stabell and Fjeldstad, 1998). The shop value creation logic (Stabell and Fjeldstad, 1998) is associated with iterative problem-solving sequences and the customization of deliveries to unique customer needs. This stands in contrast to chain value creation where a certain level of standardization must be pursued in order to enable sequential activities in line with a transformation process (Thompson, 1967; Stabell and Fjeldstad, 1998; Christensen *et al*, 2009). The chain logic is what we most often associate with traditional product-manufacturing firms, and the shop logic with for instance consulting firms. The two ways of creating value that these logics describe involve different modes of interaction with customers and therefore also different settings for pricing activities.

This article focuses on organizations that utilize shop logic value creation as a key part of their value creation activities. The studied organizations therefore also work with higher levels of customization of their deliveries to fit customer-unique needs, such as pure customization (Lampel and Mintzberg, 1996). Such deliveries are radically different from predefined standardized products.

Most research on customization has dealt with mass customization (Spring and Dalrymple, 2000) or what may be described as one-dimensional customization (for example, Chen and Iyer, 2002; Alptekinoglu and Corbett, 2004; Ghose and Huang, 2009). In this article, we focus on industrial settings where mass customization and modularity may play a role but seldom provide enough variety to match customer-unique, specific needs. Thus, we focus on the settings where high levels of customization are needed to create a delivery that meets the customer's needs. But we also consider how firms on industrial markets combine high levels of customization with generic, standardized deliveries and how pricing activities vary between these two types of deliveries and value creation settings.

This article recognizes the varying character of different value creation logics and the varying character of offerings that these involve. It aims to outline how the pricing practice differs between these value creation settings. It specifically shows that for shop value creation, it becomes difficult to apply economic value pricing models. The article also provides an empirical example of a value creation setting, which combines the above value creation logics, and how this impacts pricing practices.

VALUE MODELS FOR CUSTOMIZED PRODUCTS

Within the literature, value is most often defined for a segment of the market (Hinterhuber, 2008a). This is also reflected in the literature on pricing processes. The two processes of pricing ('within the firm' and 'vis-à-vis customer') in Dutta *et al* (2003) as well as the pricing processes in Nagle and Hogan (2006) are largely in line with the customer value analysis process as displayed in Hinterhuber (2008b), where customer value is associated with customer segments. The value appropriation practice thus presupposes a standardized set of offerings designed for a subset of customers. Such a subset may contain several segments with varying customer value perceptions, but both levels of analysis contain generalizations of value across populations.

However, many industrial firms acting in business-to-business settings rely on segment generic offerings as well as customer- and project-specific customization. This implies that the firm must rely both on value identification for several subsets of the market (which Hinterhuber (2008a) refers to as segments) and customer-unique demands and adaptations to such demands.

On industrial markets, higher levels of customization that include widely varying customer demands for unique adaptations are not uncommon. But high levels of customization as a topic in academic writings has, for instance from a manufacturing strategy perspective, been discussed to a limited extent (Spring and Dalrymple, 2000). This may explain why pricing research has paid less attention to the particularities of pricing highly customized deliveries.

Higher levels of customization may include what Shapiro (1977) refers to as 'custom-designed', Sharma (1987) 'standard, modified to customer specifications' and 'customized product', and Lampel and Mintzberg (1996) 'tailored customization' and 'pure customization'. In pure customization (Lampel and Mintzberg, 1996), customization involves the entire production process including the design stage, in order to individualize the offerings as far as possible. This is in stark contrast to mass customization, which provides options for customization but where these options must be decided across the line of offerings *ex-ante* the actual delivery. Much research on the topic of customization has been related to the ideas of mass customization (Spring and Dalrymple, 2000) and modularity for flexibility (Kotler, 1989; Sanchez and Mahoney, 1996). Mass customization is an important factor but it is often not sufficient in order to solve customer-unique demands on industrial markets.

Generic value is mainly associated with products, whereas customer-unique value aspects are often associated with service activities (cf. Ulaga, 2003; Hinterhuber, 2008b). But the value of customization activities may well be transferred to the buyer via the physical products delivered. In Lampel and Mintzberg (1996), customization is directly associated with the physical products and the adaptation of those to customer-specific needs. Thus, customization may be an important source of differentiation towards competitors and a way of delivering customer-specific value, not necessarily as a service but also through physical entities. How can this value then be captured through pricing?

The unique customer value that is created with customized deliveries provides an opportunity for pricing based on customer value. Value-based pricing practice has been proclaimed to be the most profitable pricing strategy (Cannon and Morgan, 1990; Anderson and Narus, 1998; Hinterhuber, 2008a), and is defined by Hinterhuber (2008a) as follows:

> Customer value-based pricing approaches use the value a product or service deliver to a predefined segment of customers as the main factor for setting prices. (Hinterhuber, 2008a, p. 42)

Thus, value-based pricing relates to a customer segment and relies on an *ex-ante* defined level of customer value. However, for a customized delivery, the value delivered is not defined *ex-ante*, and neither is it relevant across a customer group, but unique for an individual customer.

Descriptions of pricing for high levels of customization, that is working according to a shop logic, are rather scarce but can be found for instance in association with consulting firms. Løwendahl's (1997) theories on professional service firms can illuminate different possibilities in association with pricing. The close client relationships often developed when working with high levels of customization provide an opportunity for the supplying firm to gather insights on perceived value for specific customers. Dawson (2005) also emphasizes the importance of customer relationships in relation to value-based pricing as this practice is likely to require a certain level of mutual trust in order to gain insights into the value effects for the customer. In turn, client relation-based strategies often rely on individually based long-term interactions (Løwendahl, 1997).

This focus on customer relationships in order to understand customer value can also be found in the pricing literature in association with perceived-value pricing (for example, Cannon and Morgan, 1990). Thompson and Coe (1997) base their reasoning on Nimer (1975, cited in Thompson and Coe, 1997) when arguing that '[t]he perceived value of a product is the price the customer is willing to pay for the total bundle of value the product delivers' (Thompson and Coe, 1997, p. 71). In a similar vein, Kortge and Okonkwo (1993) argue that the key factor in order to succeed with perceived-value pricing is to have close relationships with the customers, as the close relationships will provide the firm with information about the customer's purchasing criteria. Thus, the ability of estimating the percieved customer value appears to be the focal point when practicing value-based pricing according to the definition above.

A second main group of value models focuses on differentiation towards a reference product or the commodity value. For instance, Forbis and Mehta (1981) suggest a method for evaluating the economic value of the product to the customer (EVC). According to the method, the maximum amount a customer is willing to pay for a given product corresponds to the customer's perceived value of the product relative to the price of a reference product. The maximum amount the customer is assumed to be willing to pay is, thus, equivalent to the price of the reference product plus or minus the aggregated difference in value provided by the differentiating features of the product in question, such as difference in productivity, cost for maintenance or length of the product's lifetime. The concept of a product's estimated EVC is, according to Forbis and Mehta (1981), intended to be applied to different customer groups and product applications. Consequently, performing customer segmentation in relation to the different customer group's product preferences is necessary when applying the concept. Management consultants often recommend conducting value-based pricing, and thus estimating the customer's perceived value, according to the logic of EVC (for example, Marn *et al*, 2004).

The distinction between customer percieved value models and economic value models (cf. Nagle and Hogan, 2006) is a focus area in the pricing debate among researchers and practitioners. Smith and Nagle (2005) provide an overview of four types of value in their value cascade model. They distinguish between the following: (i) value in use, that is, the actual value to the customer of the product or delivery in use (cf. the concept of acquisition utility in Thaler, 1985); (ii) value in exchange, that is economic value, similar to the prior one, with a focus on differentiation and a referenced commodity value; (iii) percieved value, here with a focus on the percieved *market* value, that is it captures how customers percieve value, and more specifically the *economic value*; and (iv) willingness to pay.

In these distinctions, economic value depends directly on competitor reference value, and percieved value depends indirectly on competitor reference value. However, for a purely customized delivery there is little or no possibility to identify a competitor or a reference value of the delivery itself due to the idiosyncrasy involved (it may be possible to compare the resources applied but not the delivery *per se*). Therefore, for highly customized deliveries, establishing economic value related to the closest substitute becomes difficult and firms must increasingly rely on methods for identifying value in use and the willingness to pay of the customer. Customer percieved value in these cases will, consequently, rely less on competitor comparison and more on the value in use. Thus, distinguishing between highly customized deliveries resulting from a shop logic, and generic and standardized delieveries resulting from a chain logic is highly important as they involve two very different settings for value-based pricing.

What are then the characters of the logics that generate these types of deliveries? Value creation logics (with references to Thompson, 1967; Stabell and Fjeldstad, 1998) focus on the internal arrangement of activities to fit external interaction, and thus build directly on Porter (1985). The chain logic adheres to Porter's value chain and Thompson's long-linked technologies and is based on the sequential arrangement of activities according to an input–output business model. The shop logic, on the other hand, is associated with customization, that is the adaptation of solutions to customer- or project-specific needs (Stabell and Fjeldstad, 1998). Thus, the shop logic is characterized by an iterative problem-solving process, most often conducted in close interaction with the customer. When firms combine these two logics, customer value can be the outcome of shop logic value creation activities on top of chain logic value creation activities.

The shop logic is typical for professional services (Stabell and Fjeldstad, 1998) such as management consulting services, engineering consulting services and investment bankers (Løwendahl, 1997). However, professional services, or service offerings in general, are not confined to shop logic value creation. Løwendahl (1997) illustrates this by identifying how professional service firms can utilize *ex-ante* R&D-like investments in order to facilitate service execution, where the execution phase resembles chain-like models. Christensen *et al* (2009) also show how the distinction between shop and chain logic, and thus the distinction between customization and mass-market approaches, includes product as well as service offerings.

Table 1 summarizes the character of offerings and the underlying value creation logics associated with it. In the table, we make a primary distinction between high levels of customization, requiring customer- and time-unique efforts, and generic offerings plus mass customization options provided by *ex-ante* investments. Of course, we may also see combinations of these in accordance with Thompson's (1967) combinations of technologies and Stabell and Fjeldstad's (1998) hybrid forms. However, given the abstraction in the table, which focuses on value creation, we may now begin to consider pricing practices, that is a mean for value appropriation, in relation with each type of value creation.

In the following section, we turn the attention towards pricing practices in relation to two types of value creation logics, shop logic and chain logic, in an attempt to enrich the understanding of pricing practices.

Table 1: Offerings characteristics and value creation logics

Value logic model	*Offering characteristics*
Shop logic	Higher level customization
Chain logic	Customization through modularity Generic offerings across markets and segments

PRICING PRACTICES

Value creation and pricing practices

Dutta *et al* (2003) propose two pricing processes, the internal process and the process vis-à-vis customers. The internal process precedes the one vis-à-vis customers for firms relying strongly on generic deliveries and chain logic value creation. This is due to the setting of prices over a larger population of customers (a market segment) which the product or service will serve. For an illustration of how this type of value creation influences the pricing process, see for instance Bernstein and Macias (2002). However, for a firm relying primarily on a shop logic, price setting has the tendency of varying more case by case and customer by customer. Therefore, when applying value-based pricing, generic price guidelines across populations are likely to be less influential. Instead, the shop logic's iterative and most often close interaction with customers provides a platform for in-depth gathering of data in order to estimate customer value in use.

The character of the supplier–customer interaction contains two elements. One relates to the long-term relationship, which consists of a stream of projects and deliveries. The other is the short-term iterative interaction, where the supplier and the customer typically start off by identifying a problem to be solved through a pre-study. After that, a first agreement is made that includes a compensation target for the supplier for the solving of the problem. This first phase, which in itself creates customer value (compare consultative services for product selection in Hinterhuber, 2008a), is the one that has the strongest iterative character. This is where customer and supplier in close cooperation try to define the problem at hand and also the value to be created in the succeeding activities. The value of this initial process is partly overlooked by, for instance, Weiss (2002). For consultative services associated with product choices (Hinterhuber (2008b) with references to Corey (1989); DeVincentis and Rackham (1998)), this phase may very well be prominent. Thus, the value of the problem-defining process must be included explicitly in the total customer value created.

The next stage is the execution phase. Here too there is often a possibility for renegotiation if the problem at hand needs to be redefined. This stage also requires close interaction (cf. Løwendahl, 1997) as it revolves around problem-solving together with the customer. The iterative character of both of these phases increases the intertwinement between the internal price-setting process and the price-setting process towards the customer. This tendency becomes especially clear if a value-based pricing approach is applied.

Such a value-based pricing situation needs to be managed at a local level close to the customer owing to its iterative character. This is in line with Nagle and Holden's (1995) reasoning, where value-based pricing authority is seen as most appropriately given to staff close to understanding the customer value of deliveries. In turn, this reflects how shop logic firms depend on key individuals who maintain close customer relationships.

Thus, the above applies for deliveries with higher levels of customization, which cannot be prepared for *ex-ante* by modular approaches (such as suggested in Wardell *et al* (2008)). Pre-defined segment generic deliveries and modular entities, on the other hand, facilitate the separation of the internal and external price-setting process and, accordingly, a centralization of internal price setting towards a predefined customer segment. However, determining the unique value to the specific customer of a generic delivery is still important (see Hinterhuber (2004) for illustrations of the need for customer-unique value assessments). Hence, it is important to separate customer-specific value associated with a generic product or service and value stemming from a truly customer-unique delivery.

Consequently, we can claim that customer-specific value contains two parts. The first part refers to differences in customer value of generic solutions between different customers within the same segment (see for instance the case of a large customer in Dutta *et al* (2003) where specific attention was given beyond normal bargaining boundaries, that is unique value was supplied to the specific customer although the solution was generic.) The other part is the result of customer unique value resulting from value creation activities directed towards the specific customer.[1] This is of course similar to customer segmentation limited to singular customer instances. Note, however, that the value delivery towards the single customer, when following a shop value creation logic, has unique features owing to the iterative customer interaction and problem solving. From a pricing perspective, it is therefore important to separate pricing processes associated with a generic delivery across a segment versus the customer-specific value associated with the unique delivery. This distinction is only partly covered by Dutta *et al* (2003) through their division between internal and customer-oriented pricing processes.

Generic pricing guidelines and the internal pricing process (Dutta *et al*, 2003) rely on value creation decisions made prior to the pricing process. The value creation decisions concern generic solutions across customer segments. Such decisions in turn rely on the anticipation of future customer value for new products or services. For efforts that involve higher levels of customization, the price process must instead increasingly be local in the internal sense as well (as defined by Dutta *et al*, 2003). This stands in contrast with Hinterhuber (2008a), who advocates that pricing should be managed at the highest level of the organization, with the exeption of those situations when the local sales representatives have a better view of the customer's willingness to pay. Under these circumstances, Hinterhuber (2008a) recommends softer restrictions regarding the sales representatives authority to give discounts. However, Hinterhuber (2008a) assumes generic value creation across a customer segment. For local value creation, in accordance with a shop

Table 2: Pricing practices settings and value creation logics/offerings characteristics

Pricing practice and authority	*Chain value creation/generic and modular offerings*	*Shop value creation/High level customized offerings*
Cost-based	Resources applied ex-ante (non-variable costs) through development of generic products or services + direct costs of application (chain-like transformations). Costs related to units or objects transformed.	Direct application of resources to customer problems – often a strong dependence on human resources. Costs are customer allocated.
Competition-based	Comparison of generic deliveries (products or services) pricing across segment or market	Comparison of resources (cost-based) price levels – idiosyncrasy limits comparison of competitor offerings from a delivery value perspective.
Value-based	Economic value models (and customer value models)	Customer value based primarily on value in use (and willingness to pay)
Pricing authority	Primarily centralized	Local

logic, a centralized pricing authority is not optimal as the individual sales representatives hold the specific knowledge regarding the customer and the unique delivery in question. Table 2 provides a framework of how organizational dependence on chain versus shop value creation impacts cost-, competition- and value-based pricing approaches. It also shows the primary focus of pricing authority.

The main finding in Table 2 is the varying opportunities for applying value-based pricing methods. When creating value according to a chain logic, economic value models are the prime basis for pricing practices. However, for pure shop logic value creation the focus must increasingly be directed towards the value in use (and the customer's willingness to pay) owing to the high levels of customization and limited competitor comparison.[2] Thus, managers need to carefully consider the pricing implications of depending on either of these two value creation logics. The next section illustrates the pricing dilemma of an industrial firm relying on a combination of these two value creation logics and especially the difficulties of pricing in association with a shop logic.

Empirical example

Departing from the theoretical field of value creation logics (Stabell and Fjeldstad, 1998) and value appropriation by the means of pricing (for example, Dutta *et al*, 2003; Hinterhuber, 2008a), the empirical section of this article is based on a single case study (Eisenhardt, 1989; Yin, 1994). The purpose of the empirical section is mainly to support the theoretical discussion and illustrate how pricing practices vary with the value creation setting (shop logic and chain logic).

The case firm of this article is the number one provider in the world of polymer foam for the oil and gas industry, employing approximately 1300 people at five different sites located in the United States and Europe. In 2009, sales were 300 million euro, of which 90 per cent was directed to the oil and gas industry worldwide and the remainder served a variety of other markets, such as renewable energy and aerospace. Approximately 80 per cent of the deliveries are more or less purely customized, albeit that the core technology is the same and that modules are reused to some extent. Roughly 90 per cent of the turnover results from a few but large and global customers, whereas the remaining 10 per cent stems from a large number of small players. The firm is in a beneficial position after many years of relatively high and stable profitability.

The case firm was selected for this study partly as it operates in a mature industry, where 80 per cent of the product portfolio consists of customized products. Another reason for choosing this firm was the fact that customers consider the products to be of high quality, mainly owing to a proven track record and a strong technical expertise (according to an independent market research firm). Moreover, the firm's prices are approximately 5–10 per cent higher than its competitors' prices. Yet, as the focus on costs has increased among customers, competitors have started to gain market shares. In conclusion, the firm appears to be in a good position for applying value-based pricing practices, especially for customized aspects of its deliveries.

In total, 15 individuals were interviewed at two of the sites in Europe from 2006 to 2010, including the manager of customer relations, department managers, development managers and sales and product managers. Each interview lasted approximately 1 hour and was recorded and transcribed. The interview questions concerned: (i) delivery, design and production characteristics and the process of value creation; and (ii) the pricing practice, customer relationship management, sales and marketing.

Value creation and pricing practice at the case firm

The case firm reveals characteristics related to chain logics as well as shop logics. One of the managers describes the deliveries that they supply as follows:

> If you look at this, it's not one product. You do things that the customer wants for every occasion. You may say that some of the applications are the same but the product doesn't look the same from one time to another.

The above quote illustrates the high level of customization of deliveries: that every delivery or every project is 'unique' for each customer and occasion. However, it also indicates that some things stay the same from time to time. Thus, there is an amount of repeatability present in order to capitalize on scale economies. The varying starting points of customization projects can be further seen in this comment from one of the development managers:

> One philosophy of mine is to utilize as much as possible of already developed materials. Or to adjust a developed material that exists. That way is a lot shorter.

This illustrates the character of deliveries and value creation in the firm where a high level of customization co-exists with a search for repeatability in design but also eventually in production processes. This provides a value creation setting that pricing activities depend on.

The current way of setting the prices is very individual, depending on the different sales representatives. List prices are used only to a very limited extent. One of the product managers explains it as follows:

> Setting the price is a trial and error thing and it is also [based on] the ability to understand what's been going previously with the customer.

In a similar vein, one sales manager states:

> There is no rhyme or reason really to how we price our work, it is largely experience based.

Moreover, as the following quote by one of the sales managers tells, no customer segmentation is performed:

> For every customer, we have a different profitability for sure. I mean, it's all historic. But we've got no way of tracking it either because we haven't got sophisticated enough systems to do that for us.

This shows a firm depending on close relationships with its customers. The limited use of list prices indicates that prices largely are set per customer and delivery. It also shows the dependence on local pricing authority based on the experience of sales staff, rather than a centralized pricing model.

The firm has close, long-term customer relations and a good knowledge about the customers' needs. Customers are paying a premium for the 'high customer value', the 'extra service provided' and 'convenience' as the firm, in many cases, functions as a 'one stop shop'. One of the product managers explains it as follows:

> We don't necessarily want to be the cheapest in the market place, we want to be the best in the market place. So we want to add value in terms of delivery service, product and price, so it is a package and we want them to pay for our premium service.

When setting prices, the sales and product managers rely on their qualitative feeling when estimating the customer value and identifying the strengths of their products relative to competition. They depend on their experience from customer history and previously made deals. The prices are thus based on cost plus markups and customer history. When handling a new customer, or the situation of a customer buying a product that is different from previous purchases, the prices are set on a trial and error basis guided by the target margin. As expressed by one of the product managers:

> If we have no customer history, we don't know what their expectations are, then really we haven't got anything to go on [with regard] to what their price expectations is. You might have a general feeling that, within a certain range, maybe within a certain region, that it is a market where you have to be really competitive or you might have a feeling that it's a new market, and maybe you can be quite relaxed with your pricing. But usually at that point, in order to measure it, you come back to the cost plus the margin, and we use the margin to regulate whether we are going relatively high or low compared to an average margin figure.

Considering that the case firm sells highly customized, premium products with fairly high margins as compared to its competitors, the challenge is both to communicate the extra value added to the customer and securing that the customer is paying for the extra value. One of the product managers explains it as follows:

> The real challenge in making a sale is to make a sale on our terms and get the client to accept what we are saying to them. So what we think is that we are reasonably good at differentiating ourselves technically towards our competition. And also that [we are] adding some value [compared] to the competition, so that the client will pay a premium for our products. Maybe that they are getting better service from us in terms of the relationship, that we visit the client regularly and we solve that problem with them together, or maybe that we offer a real secure track record.

The above quote illustrates how differentiation and direct competitor comparison appears on a generic service, product and resource level and not primarily on a delivery level. Thus, economic value pricing models can be used for the resources of the firm and its generic products and modules, but not for the value created by iterative joint problem-solving with the customer. For such specific customized aspects of deliveries, direct comparison with competitors becomes difficult owing to the idiosyncrasy involved. Instead, the firm has to rely on the in-depth experience of the customer and the specific value in use that can be foreseen.

Altogether, the case illustrates a setting with high levels of customization of deliveries and how this influences pricing activities. As shown, close interaction and long-term relationships are central in order to communicate customer value and to be able to price accordingly. Furthermore, the case indicates the difficulties of direct comparison with customer offerings owing to high levels of customization. As deliveries vary towards each customer and project setting, direct competitor comparison on a delivery level becomes more difficult to implement. Consequently, the ability to quantify the customer's economic value as recommended by the EVC model (Forbis and Mehta, 1981) is limited and, moreover, the customer value has to be estimated for each individual customer rather than for a given customer segment.

However, the close relationships with the customers open up for potentially strong customer value in use analysis, which may enhance customer value-based pricing approaches. Close relationships with customers are intrinsically linked to shop logic value creation, as it requires iterative problem-solving together with the customer, which may provide deep insights into the value in use and the willingness to pay of the customer. Thus, the case illustrates how shop logic dependence, and thus high levels of customization, is a setting in which economic value pricing models are difficult to apply but where the firm instead must focus on the value in use and the willingness to pay of the customer. Competitor comparison for customized deliveries will most often be limited to the resources applied.

CONCLUDING DISCUSSION

This article applies a different perspective than, for instance, Hinterhuber (2008b) in trying to associate pricing with different types of value. This article also goes further as it more closely tries to pinpoint how pricing activities depend on the value creation logics of the firm. By doing so, the article recognizes the role of pricing in a wider organizational and strategic context of the firm.

Recognizing the distinction between value creation and value appropriation is highly important as it clarifies the role of value appropriation, and pricing in particular, as a source of competitive advantage. However, as this article indicates, the pricing context varies significantly depending on the offerings and the value creation logic of the firm. It is therefore important to take into consideration interdependencies between value creation and value appropriation activities. In this article, it is shown how dependence on customization versus generic deliveries provides different opportunities for realizing pricing processes resulting from various types of customer interaction in association with value creation. The pricing process in association with a shop logic involves an intertwinement of the internal and customer-oriented pricing processes (as they are proposed by Dutta *et al*, 2003).

This article applies value creation logic analysis, within an industrial market context, in order to determine the context in which pricing practices occur and thus how they depend on the value creation logic. We show how the partial dependence on shop logic value creation provides a specific context in which pricing activities occur. Additionally, in Table 2 we outline the pricing implications of depending on a shop or chain logic. This is the prime theoretical contribution of the article. Further research should continue exploring pricing practices within different value creation contexts. This article has for instance not covered pricing activities in settings with a strong network value creation logic (Thompson, 1967; Stabell and Fjeldstad, 1998).

The prime contribution to value-based pricing models in shop logic settings today comes from the professional service firm literature. However, as the case in this article shows, value creation according to a shop logic, and pricing associated with it, is present in many industrial firms. Thus, research and practitioner development of new or improved customer perceived value models for shop logic value creation on industrial markets are highly important.

The managerial implications of this article are primarily related to the overview of pricing settings associated with the shop and chain value creation logics. This article shows what type of pricing methods managers should focus on, depending on the value creation setting. Especially, when applying a value-based approach to pricing, firms must direct their attention to customer value pricing models based on the value in use, when working mainly according to a shop logic. But as shown in this article, the reality is often a combination of chain and shop logic value creation. Thus, one of the primary challenges for pricing on industrial markets lies in combining various value pricing models.

In conclusion, firms that combine chain and shop value creation should apply a two-layer approach to pricing. From a value-based pricing perspective, this means, first, the firm should utilize economic value pricing models for the generic aspects of products and services in association with chain value creation. For these parts of the value created, the firm should also establish a centralized pricing authority.

Second, the firm should utilize customer value pricing models, based on value in use, for the customized deliveries in accordance with shop value creation. This should be complemented with competitor comparisons of the resources employed to supply highly customized deliveries. For these parts of the value created, the firm must increasingly apply a local pricing authority owing to the idiosyncrasy and local uniqueness of value creation.

Managing customer value for the highly customized parts of deliveries thus becomes a challenge that requires a focus on information stemming from each specific customer. For instance, information management must focus on data regarding customer profitability, typical use cases of the customers and their profitability, and the customers' business cases towards *their* customers. However, the firm must also complement this by gathering competitor data related to the resources utilized in creating customized deliveries.

Firms that combine a shop and chain logic in value creation must in turn combine the customer-specific information management with the traditional information management utilized in association with economic value pricing models. Such a combined pricing model should be done in a clear two-layered approach, which enables a distinct view of the generic value and the customer-unique value, respectively.

NOTES

1 There is also a time aspect of customer uniqueness that we do not consider in this article.

2 Here we assume that the firm optimizes its use of the chain logic and thus transfers customized activities that can be solved in accordance with a chain logic owing to repeatability towards a single customer or generalization across populations. That is, customized, shop logic-generated deliveries have truly unique features that create local barriers of entry.

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Futures

Value pricing when you understand your customers: Total cost of ownership – Past, present and future

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Todd Snelgrove

SKF USA Inc. USA

Todd Snelgrove is Global Value Manager for SKF, the world's market leader for bearing and related industrial products. He leads the company's worldwide initiatives to demonstrate the total value of SKF's offerings to actual and potential clients.

Correspondence: Todd Snelgrove, SKF USA Inc, USA
E-mail: Todd.c.snelgrove@skf.com

ABSTRACT At the heart of pricing and selling in the twenty-first century is the ability to price based on created value. In this context, total cost of ownership (TCO) plays an important role. Historically, both academics and practitioners have included exclusively elements related to cost reductions in TCO calculations. In this article, we point toward emerging practices of including not only cost elements, but also all differentiating elements that contribute to customer value in TCO calculations.

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IS IT LOWEST PRICE OR LOWEST COST THAT CUSTOMERS WANT?

Oscar Wilde wrote that a cynic was a person who knew the price of everything and the value of nothing. At present, that definition could easily apply to those companies that still buy products and services based on unit price alone, without considering the lifetime costs.

Has your company taken the time and effort to equip its sales team with the knowledge and tools needed to demonstrate the difference between these two concepts? Too often, people assume that lowest price is the same as lowest cost, but it is not. Those 'visible price savings' become lost as other costs increase. Price is the monetary exchange for a good or a service; cost encompasses not only price, but also all the other associated incurred costs.

Total cost of ownership (TCO) is a holistic approach that looks at the acquisition, operation and disposal of a product or service. The concept of a formalized TCO approach is generally accepted to have begun in the information technology field in the late 1980s with the Gartner consulting group. It was designed to calculate all the costs of owning a desktop device, including capital, technical support, administration and end-user costs. TCO has been used to highlight the difference between the ownership costs of a personal computer, a network computer and a Windows-based terminal (West and Daigle, 2004). It is only by comparing the total cost over the life of a product or service with the initial and ongoing expenses that we make a true comparison between alternative purchase offers.

What customers need is the lowest TCO – the best value.

In too many industries, the word 'value' has been incorrectly applied to low-priced generic brands, low-price players (LPPs) or no-frills companies. Interestingly, a 2007 study by Strategic Account Management and sponsored by the International Association of Commercial and Contract Management found that customers ranked TCO nearly two times as important as price (Strategic Account Management Association and International Association of Commercial and Contract Management, 2007). Purchasers are beginning to realize that price is just another subcomponent of TCO.

Does your company's marketing and sales people spend time and effort trying to cloak price reductions by using buzzwords such as 'volume discounts', 'new market pricing', 'competitive bid reaction', 'special industry promotions' or a host of similar terms? If you, as a pricing professional, are having these discussions with the sales force, it is likely that the team is unable to clearly explain to customers the difference between price and TCO. Ideally, the sales force spend their time creating and presenting value, rather than convincing their own management that they are pricing too high.

Existing TCO analysis involves looking closely at the three stages of ownership for users of products or services. The approach starts with a close look at the *acquisition process*, including receiving costs, payment terms, holding inventory and unit price. Next is the *operation phase*, in which the buyer uses what has been purchased. Included are factors such as product or service longevity, energy consumption and ease of use. Finally, one needs to *dispose* of what has been purchased. Disposal can range from almost free to very expensive, or the product or service might even have a residual value. These costs can vary as a result of many factors, but numerous studies show that the initial purchase price of an industrial product is less than 15 per cent of its total cost (Accenture, 2001). For example, what does the average person consider important when purchasing a car? Intuitively, one may consider the initial price. However, other factors, such as operating costs (including fuel consumption), average cost to repair or service, financing, insurance, resale value and numerous others, also influence the decision. Possessing data about all of these factors, one might find that a car that initially appears to be expensive will actually provide a lower TCO and is therefore a better deal.

Because of the wealth of data that exist in the marketplace today, applying the concept to everyday purchases is now more feasible.

Examples of application of TCO can be seen in numerous consumer purchasing decisions, for example, the white-goods appliance industry with the introduction – and adoption – of the 'more expensive' front-loading washers and dryers that use less space, energy, water and detergent to operate. TCO applies to the automobile industry as well, with the launch of electric cars, which have higher up-front financial costs but a positive payback depending on incentives and on tax and fuel savings. In the airline industry, the legacy airlines are pushing back against the LPPs to show the total cost of going from point A to B, including taxes, food, and costs of printing boarding passes, paying with a credit card and checking or carrying baggage. The list of industries providing – and proving – created value is increasing. Original equipment manufacturers (OEMs) plan the life-cycle cost of a machine during the design stage. They make decisions and design costs and know how easy it will be to operate, how much energy it will consume, and whether failures will be predictable and inexpensive to fix or catastrophic and costly. In today's market, instead of producing a 'good enough' (that is, cheap) product, OEMs are better off creating one with superior performance that can be quantifiably demonstrated to customers.

The future of TCO

The ability to price based on the value one creates is posited on one simple fact: one must create value. This might sound straightforward, but it is not.

What is value? Value exists in the eye of the purchaser or user of a product, not in the mind of the engineer who creates it. Value can be tangible or intangible. However, in the business-to-business (B2B) marketplace, the importance of tangible value is much higher than in the business-to-consumer marketplace, where one does not usually have to justify one's purchasing decisions – except perhaps to a spouse. In most B2B scenarios, the person your sales force will contact, whose problem they are trying to solve, is not the person who writes the purchase order. It is responsibility of the sales manager to support the contact person with the business justification to support the premium price of our solution, because he or she will invariably have to defend this to a boss or to procurement.

As different sectors of the population, including industries, regions and cultures, value different things, it is important to identify the values that will translate well across the greatest number of segments. In the B2B arena, we can assume that increased profitability is the main driver.

Pricing

What TCO is and value pricing is not: TCO is not a cost-based analysis tool that a company uses to look inward in order to do cost-plus pricing. TCO is a tool that can incorporate all elements that create customer value, that is, cost reductions, revenue generation, the realization of price premiums, risk reduction or working capital reductions.

Quantifying value to enable premium pricing

In the past, numerous problems made a customer's costs difficult to quantify:

- Inability to determine the value created in light of the next-best alternative. Companies were unwilling or unable to determine the true differences between the product and/or service options that customers were analyzing.
- Soft value statements such as 'premium branding', 'relationships' and 'free services' were used to describe value offered and to justify price premiums.
- Inability to quantify the financial value created by understanding an industry or company's operating parameters, and how they truly made money.

Today's proactive companies provide much more:

- Industry-, application- and customer-specific benchmarks are more readily available through industry associations.
- Government and industry provide approved calculations, for example, for energy reduction.
- Value managers at companies help to develop value-pricing sales models and explanations of that value to customers.
- Premium-value companies focus on quantification strategies that allow value pricing.

In the future, we look forward to

- The expansion of long-term 'pay for performance' contracts based on TCO.
- An increase in customer-choice pay models; pay for performance (ongoing) versus higher initial price, where the customer takes all the risk plus the benefit.
- Formalized adoption of software that allows quantification of industry-specific value that enables value pricing.

Communicating value

In the future, companies must convert the value they create into a message that can be communicated. This means abandoning traditional feature-based marketing to showing how these features create specific benefits and how they in turn affect customer profitability. Companies will then be able to reposition their price premium as an investment, as customers will see the incremental return they receive.

Pricing for value created

Value-based pricing is not about extracting all the incremental value through price premiums. This tactic leaves the customer indifferent, and lacking incentive to keep buying one's offering instead of the next best alternative (NBA). Extracting all the incremental value leads customers to seek new options that create more value or the same value and that are lower-priced, or a combination of the two.

A customer's willingness to pay and their ability to pay are very similar if a company is able to quantify the benefits. Assuming customers wish to gain the greatest economic benefit, then this benefit will be based on such factors as the believability of your argument, the timing of the customer's cash flow and their alignment on TCO procurement.

Process of setting new prices

In the future, more decisions for pricing new products should follow a value-created model rather than cost-plus methodologies. Suggestions for sales and marketing personnel include:

1. Measure the economic benefit for different customers (minimum, maximum, average).
2. Determine cost to produce. If cost exceeds customer value, stop, or improve the value.
3. Set the price that allows the customer to achieve a benefit greater than the investment.
4. Use sales, marketing and new-product iterations to either increase the benefit or reinforce what the realized value was.
5. As realized and understood value increases, you can increase prices.
6. Use efficiencies in your processes to reduce costs and increase profit.

The results are happier customers who are realizing greater value by working with you. As the value creator, you can realize higher prices, increased sales and a faster sales cycle, all of which lead to greater profitability.

Quantifying value in TCO calculations in the future

The expansion of the analysis to quantify the total value created. By value, we mean profit. Existing TCO analysis looks at the cost side of the equation and reducing the total amount of it. In the future, TCO calculations will be all about quantifying the total value created for customer: Customer value creation can take many forms: increased revenues, increased price premium, reduced risk, reduced working capital or fixed capital investment or any other level which positively impacts a customer's profitability.

The future of ways to get paid for value

A premium price is the easiest way to visualize capturing value created. However, other ways exist, and are becoming more palatable for customers:

- *Performance-based pricing*: Charging for the actual performance improvement at a preset ratio of incremental realized value. Companies pay the old amount for a similar product they are accustomed to; as value is created, they pay the price premium (for example, at a ratio of 50:50) until it is paid off; then, as value exceeds the total cost of the new solution, they pay the supplier a performance-based reward of 20 per cent, to reflect the fact that the supplier takes considerable risk up front and the consumer does not.
- *Increasing share of business*: Sometimes it is easier for procurement to increase scope than increase the price paid.
- *Non-discounting of other business*: Instead of charging a 30 per cent premium on a range of solutions, not discounting others might have the same desired impact and be easier for the purchaser.
- *Lengthen the time frame of the agreement*: Instead of re-bidding every 3 years, increase the length of an agreement.
- *Charge a consulting fee for the value created*: If it was your knowledge that found a problem

and addressed it, it might be easier to write a check to cover service fees.

Sometimes a combination of the above is the easiest and most palatable for the customer. As pricing professionals, we need to ensure that we are paid for the value created; however, we also need to give customers alternatives to choose from.

CONCLUSION

If you can prove the value of your product or service by measuring it in 'hard' monetary terms that the customer understands, your price premium can be seen as an investment. However, without the backing of data, financial models and in some cases guarantees of minimum value created, you leave procurement people no choice but to discuss price.

Advanced companies in numerous industries support the investment they make in developing new products and creating customer value. Supporting value pricing and sales with the right tools, processes and people enables you to present a premium-priced product to customers so that they see, realize and understand the reasoning behind the premium price and are willing to pay it.

Advanced companies are now looking at both sides of the income statement when making business decisions. How can I reduce my costs using existing TCO methodologies and how can I increase my revenues, thus allowing for a true analysis of what is the best deal.

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Research Article

Differential pricing at domestic and international airline gateway hubs

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Brenda Kahn[a] **and Philip Kahn**[b]

[a]7728 US Open Loop, Bradenton, USA; and [b]330 N Clinton St, Apt 403, Chicago, USA

Brenda Kahn is Adjunct Professor of Economics at the University of Tampa and received her PhD in Economics from Columbia University. Before teaching, she worked at AT&T as a District Manager for more than 20 years. She was in charge of a regulatory group that managed input pricing and was an expert input pricing witness in numerous legal proceedings.

Philip Kahn is a senior analyst at United Airlines and recently completed his Master's degree in Economics from the University of Illinois in Chicago. He has been a pricing and routing analyst for United Airlines for 5 years.

Correspondence: Brenda Kahn, 7728 US Open Loop Bradenton, Florida 34202, USA
E-mail: bkahn@ut.edu

ABSTRACT This article develops and tests an analytical econometric model of pricing for city-pair airline routes. We identify an explicit role for vertical integration and input foreclosure for airlines that bundle their components into composite goods. Using disaggregated data on more than 2000 airline-specific city-pair routes over the period of the third quarter of 2006 through the fourth quarter of 2008, we test the model and obtain estimates of pricing premiums associated with hubbing, distance, market size, input foreclosure and fuel costs associated with each route. The results shed new light on the importance that international gateway hubs play on price in a sophisticated revenue management setting.

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INTRODUCTION

This article explores the issue of vertical integration and input foreclosure for airlines, which supply route segments that are bundled into a final city-pair market good. Airlines have international gateway hubs where domestic flights interconnect with intercontinental flights so as to provide seamless connections for passengers traveling overseas. We conduct an empirical study to determine whether airlines price a route segment to their rival's international gateway hubs high in order to raise the overall ticket price of overseas travel on a rival's plane.

Previous studies have either looked at pricing behavior at all the hubs of a given airline (Borenstein, 1989; Harris and Emrich, 2007; Lee and Luengo-Prado, 2005) or examined code sharing where two carriers share revenues on flights (Gayle, 2007; Lee and Ito, 2007). We differentiate ourselves from those studies by examining how an airline prices domestic segments of international overseas flights that either inter-connect through its own international gateway hub to the final international destination or interconnect through a rival's international gateway hub where the rival flies the passenger on the overseas leg. A previous study examined whether large domestic networks improve the international competitive position of airlines (Clougherty, 2002). The main conclusion from that empirical study is that US airlines improve their international competitive position when they match their extensive domestic networks with their international routes. The next section of the article provides the justification for the study methodology, while the following section discusses the data and estimation results of the study. The final section provides some concluding comments.

MOTIVATING THEORY OF VERTICAL INTEGRATION, RAISING RIVALS' COSTS AND UPSTREAM COLLUSION

Airlines are often categorized by the topography of their network routes. Terms such as hub and spoke, end to end or fortress hubs tell about the network routing patterns of an individual airline. In our article, we have used international gateway hubs to describe major interconnection points within an airline's network structure. International routes are highly profitable for major US Airlines. Table 1 presents data collected by the Bureau of Transportation Statistics (BTS) of the US Department of Transportation from the major US airlines for the first nine months of 2006 which constitutes a portion of our study period. The data show that international operations were five times more profitable per passenger than domestic airlines. International operations provided only 26 per cent of the revenue of major US airlines and only 12 per cent of the passengers, but generated 40 per cent of the operating profit. The average passenger provided US$35 in profit on an international flight and $7 in profit on a domestic flight.

Table 1: Major US airline profitability measures 2006, Q1–3

Financial results ($millions)	*Domestic*	*International*	*Total*	*Domestic (%)*
Operating revenue (OPREV)	82 939.00	29 191.40	112 130.40	73.97
Operating expense (OPEXP)	79 596.50	26 884.20	106 480.70	74.75
Operating profit (OPPRO)	3342.70	2307.30	5650.00	59.16
Net income	10 782.70	8994.40	19 777.10	54.52
Passengers (PASS) millions	496	66	562.00	88.26
Flights (FL) millions	7.30	0.648	7.95	91.85
Passenger trip length (miles)[a]	876.6	2573.3	1075.9	
OPREV/Pass	$167.22	$442.29	—	—
OPREV/FL	$11 361.51	$45 048.46	—	—
OPEXP/Pass	$160.48	$407.34	—	—
OPEXP/FL	$10 903.63	$41 487.96	—	—
OPPRO/Pass	$6.74	$34.96	—	—
OPPRO/FL	$457.90	$3560.65	—	—
OPEXP/PASSxMiles	$0.1831	$0.1583	—	—

[a]The average distance flown per passenger is in miles.

Data presented in this financial and traffic review are derived from data reported to the United States.

Department of Transportation on Form 41 Schedules by Large Certificated Air Carriers.

This analysis is limited to the major scheduled passenger and all-cargo air with revenues exceeding $1 billion per year. 'Domestic' encompasses operations within and between the 50 states of the United States, the District of Columbia, Puerto Rico and the US Virgin Islands. It also encompasses Canadian transborder operations for certain carriers Mexican transborder operations. All other operations are considered 'international'.

Source: Bureau of Transportation Statistics, T-100 Market and Segment.

We want to indirectly examine whether airlines act to improve their international competitive position by adding domestic feed to international flights so as to achieve density economies on international service. Previous authors have determined that density economies on international service are important motivators for mergers (Dresner, 1994; Clougherty, 2002).

In order to achieve substantial density on international flights, the major US carriers direct their overseas flights to specific areas of the world. Table 2 provides international passenger data collected by the BTS of the US Department of Transportation, Office of Aviation Analysis, Competition and Policy Analysis Division from the major US airlines for 2007. Carrier-specific international passenger counts by city destination identify the major overseas international cities served by each carrier. United Airlines, Northwest Airlines and American Airlines (AA) have a large presence in Asia. Delta, Continental and US Air primarily serve European cities. In 2007, AA was the largest US-owned international carrier and the only major carrier to fly more than a million passengers to Asia, Europe and South America, respectively.

Table 2 also presents the relative importance of each carrier's international gateway hub. The largest international gateway hub is AA Miami Airport. Flights to South America, Mexico and the Caribbean go through this city. The largest international gateway hubs which predominately serve overseas cities are Continental's hub at Newark Airport and Delta's hub at Atlanta.

In analyzing various types of networks, recent authors have noted that network elements frequently consist of both competing and complementary brands of compatible components (Economides and Salop, 1992; Economides, 1998). Complementary components can be integrated to produce composite products, which are substitutes for one another. Composite good competition is prevalent in many network industries such as telecommunications, banking and the airline industry. An airline passenger flying overseas on a one-stop itinerary can use the same airline for the entire trip or change airlines for the second part of the trip. In this case, the components are the individual trip segments.

Vertical integration is a common network market structure that is applicable to our study of international air travel. Under vertical integration, firms produce and sell complementary components in addition to a composite product made up of its components. In the past 20 years an extensive literature has developed which describes the circumstances by which a vertically integrated firm has incentives to engineer an increase in rivals' costs by its behavior in the upstream component market, **U1** (Salop and Scheffman, 1987; Economides and Salop, 1992; Riordan, 2008; Normann, 2009). The vertically integrated firm can raise rival's costs by refusing, degrading or increasing the price of access to an important input for which there are no close substitutes ('input foreclosure').

In a recent article, Normann shows that in a repeated stage-game, a vertically integrated firm which adopts a raising-rivals' cost strategy can achieve a joint profit-maximizing equilibrium. In this model, there are $n=2$ (or more) upstream firms and $m=2$ (or more) downstream firms. The upstream firms are U1 and U2, and the downstream firms are D1 and D2. The integrated firm will be called U1-D1. The upstream firms produce a homogeneous input. D1 pays its marginal cost for the input and D2 transforms the input into a final good for which D2 pays a linear price, c2.

As Normann shows, when the input market is collusive, in a repeated game a raising rivals' costs strategy is an *effective* profit-maximizing equilibrium, even though such a strategy is not a tenable equilibrium of the static game. In the static game, the integrated firm, U1-D1 has an incentive to cheat and undercut U2's input price. U2 will anticipate this deviation and both firms will end up charging a price equal to marginal cost which mitigates the higher downstream profit associated with the raising rival's costs effect. In the repeated game, when

Table 2: International passengers by city and carrier (2007)

UA City	*Pass*	*CO City*	*Pass*	*DL City*	*Pass*	*NW City*	*Pass*	*AA City*	*Pass*	*USAir City*	*Pass*
2007 Passengers (000)											
Tokyo	661	London	289	Paris	245	Tokyo	1117	Tokyo	2446	Frankfurt	176
London	585	Paris	219	London	245	Amsterdam	871	London	969	London	132
Frankfurt	550	Amsterdam	169	Rome	213	Osaka	233	Paris	313	Rome	74
Beijing	246	Tel Aviv	167	Frankfurt	209	Guam	232	Sao Paulo	293	Paris	72
Hong Kong	212	Tokyo	150	Sao Paulo	125	Saipan	161	Caracus	285	Manchester	72
Shanghai	175	Manchester	99	Amsterdam	124	London	156	Buenos Aires	244	Madrid	67
Sydney	160	Lima	94	Madrid	113	Nagoya	133	London (GAT)	174	Munich	50
Osaka	134	Madrid	92	Milan	106	Manila	100	Lima	141		
Munich	131	Dublin	83	Manchester	101	Santiago	100	Bogota	127		
Amsterdam	125	Sao Paulo	82	Dublin	100	Frankfurt	86	Brussels	117		
Paris	125	Rome	81			Paris	80				
Asia/Australia		1588	150		0		1976		2446		0
Europe/Israel		1516	1199		1456		1193		1573		643
South America		0	176		125		100		1090		0
International gateway hub 2007 passenger counts by carrier											
Chicago	1526	New York	3200	Atlanta	3304	Detroit	1373	Miami	4171	Philadelphia	1156
San Francisco	1380	Houston	2246	New York (JF)	1385	Minneapolis	889	New York (JFK)	1746	Charlotte	866
Washington	1166	Cleveland	23	Cincinnati	207	Memphis	171	Chicago	1176	Las Vegas	26
Los Angeles	447			Los Angeles	155	Seattle	162	Los Angeles	357	Phoenix	87
Seattle	74			Salt Lake	108	Los Angeles	124	San Francisco	73		
Total Int'l Pa	5121		5451		5239		3707		9860		2251
UA Rival is NW	—	CO Rival is AA	—	DL Rival is AA	—	NW Rival is UA	—	AA Rival is DL	—	All are rivals	—

the one time gain from deviating today is smaller than the loss owing to punishment made in every future period, then the upstream firms will maximize their joint profits through collusion. Normann solves for the lowest minimum discount factor applied to future losses, which would be required for firm U1 and U2 to maintain a collusive pricing strategy and maximize joint profits.

Vertical integration plays a pivotal role because self-supplied input requirements are insulated from degradation and/or price increase. Consequently, the input provided to the downstream competitors impacts the costs of the integrated firm and its downstream competitors asymmetrically. This strategy benefits the downstream operation of the integrated firm by causing rivals to exit the market or otherwise reduce their supply of the final good.

An alternative scenario that Normann evaluates is a counter merger by which U2 and D2 increase their joint profits by vertical integration. In order to prevent the counter merger, U1-D1 has to limit the price of its input, c2. If there is already another vertically integrated firm, U2-D2 in the market, the raising rivals costs strategy becomes *ineffective* since the input price, c2, is seldom paid by the downstream firm D2. In this scenario, we have parallel vertical integration.

In our application of Normann's paradigm, we assume that the downstream good is an international flight originating from an airline's international gateway hub and the upstream good is a domestic flight originating from an airline's non-international gateway hub. A rival downstream firm, by promising to pay the integrated supplier a profit on upstream sales, weakens the integrated firm's incentive to compete aggressively in the downstream market. However, U1-D1's downstream price, p1, must be factored into its choice of c2, its upstream price. In other words, the integrated firm must treat the foregone upstream profit as an opportunity cost of winning a more profitable downstream sale. As on average airline profits from international passengers are five times greater than from domestic passengers ($35 versus $7 per passenger), the opportunity cost is relatively high. Therefore, we believe this fact justifies our application of Normann's paradigm to the data set we use in our study.

MODEL AND DATA

Previous studies have used the US Department of Transportation's OD1B Origin and Destination Survey, which represents a 10 per cent sample of all tickets reported by US Scheduled Passenger Carriers and we also relied upon these data in our study. These earlier studies such as Lee and Luengo-Prado (2005) and Borenstein and Rose (1994) measured hub premiums while attempting to control for other factors that impact average fares such as distance, passenger density, passenger mix and market share. Bilotkach (2007a, b) examined pricing at international gateway hubs located in New York City, but we have extended his study to examine pricing at the following international overseas gateway hubs: Atlanta, Charlotte, Chicago, Dallas, Detroit, Houston, Los Angeles, Miami, Minneapolis, Philadelphia, San Francisco Seattle and Washington, as well as New York. Lee and Luengo-Prado (2005) also differentiated between primary and secondary hubs, but did not differentiate on the basis of international and non-international gateways hubs. We also control for these factors and also add in the cost of fuel.

Most international gateway hubs are also domestic hubs for the airlines. International gateway hubs include Chicago, Dallas and Miami (AA), New York and Houston (Continental or CO), Atlanta, Cincinnati and New York (DL), Detroit and Minneapolis (Northwest or NW), Chicago, Los Angeles, San Francisco and Washington (United or UA) and Charlotte and Philadelphia (US Air or US). However, several domestic hubs were not used as international overseas gateway hubs by US carriers during the period of our study. During our study period non-overseas gateway hubs included St Louis, (AA), Cleveland, (CO), Salt Lake City (DL), Memphis (NW – with the exception of a flight to Amsterdam), Denver (UA) and after the merger between US Air and America West, Las Vegas and Phoenix (US).

In particular, we examine pricing on all major city-pair routes from each of the carrier's non-overseas gateway hubs. Individual carrier routes are divided into four categories and pricing is then compared between the various categories. The first category encompasses major domestic city-pair routes from the carrier's non-overseas gateway hub to an international overseas gateway hub within the US. The second category includes domestic city-pair routes from the non-overseas gateway hub to major domestic cities that are not international gateway hubs for the carrier. The third category includes domestic city-pair routes from the carrier's non-overseas gateway hub to major cities that are overseas gateway hubs for competing overseas carriers. City pairs are only considered major city pairs if there are a minimum of 100 daily passengers for the quarter of the year being evaluated. The fourth category adds domestic city-pair routes between the carrier's overseas gateway hubs as a control in some of the model results.

As an example of how we differentiated categories, Delta's non-overseas gateway hub is Salt Lake City (SLC). Delta passengers originating in SLC will fly to Atlanta or New York's JFK Airport, when they are traveling to Europe. Atlanta and New York's JFK Airport are Delta's primary international overseas gateways and are included in category 1. Interestingly, Delta does not fly between SLC and Cincinnati, its third international gateway hub. Delta also flies scores of routes from SLC, which terminate in many cities such as Boise, San Francisco, Las Vegas, Phoenix and Portland. City-pair routes, which are not components for non-stop flights overseas that compete with Delta's overseas flights are included in category 2. Cities such as Boise, Las Vegas, Phoenix San Francisco and Portland are included in category 2, as they are either not international gateway hubs or are non-competing international gateway hubs such as San Francisco and Portland. While San Francisco and Portland are trans-Pacific overseas gateways for United and Northwest, Delta only flies from Atlanta on trans-Pacific routes and therefore is not directly competing for SLC passengers traveling to Tokyo. City-pair routes such as SLC to Chicago and New York Liberty Airport are international overseas gateways for Delta's competitors. AA flies direct routes from SLC to Chicago and Continental flies direct routes from SLC to New York Liberty Airport. These city-pair routes are included in category 3. Flights between Atlanta and New York's JFK Airport are placed in category 4.

Researchers such as Berry and Jia (2008) and Gayle (2007) have found that passengers prefer to travel non-stop whenever possible. Overseas flights that do not originate from an international gateway hub city generally require passengers to fly first to an international gateway hub rather than fly non-stop from their point of origin. When international carriers establish airfares on international routes, they must take account of the explicit domestic price charged for the domestic leg of the flight between the passengers' point of origin and the carrier's international gateway hub (IGH). It is relatively easy to arbitrage fares that are out of line. Assume that Delta charges $1500 to fly from Frankfurt to SLC (routed via New York) and $1250 to fly from Frankfurt to New York. If Delta were to charge less than $250 to fly from SLC to New York, it would make sense to buy a ticket from Frankfurt to New York and a ticket from New York to SLC on the same plane that provides the domestic segment of the international route. If Delta were to charge more than $250 to fly from SLC to New York, consolidators that have discount agreements with the airlines. In most cases, especially with the United States and other big airlines and their affiliated retail travel agencies could act as an arbitrageur and re-bundle ticket from Frankfurt to SLC (routed via New York) and sell each segment separately. In our study, we assume that the fare for the domestic segment is consistent with the implicit price built into the fares on the overlapping international routes. We will examine this assumption further in a later section of the article.

As described by Edward Hasbrouck (2008), well-respected travel expert, the revenue-maximization problem for the airlines is how to get some money for seats on international flights that cannot be filled at the official fares mandated by the International Air Transportation Association (IATA).

The system the airlines have developed for selling discounted tickets at less than official fares requires travel agents to rebate a portion of their commissions to customers. Neither IATA nor international airfare treaties restrict how much commission an airline can pay an agent for selling a ticket. Airlines are aware of this rebate practice, but they must pretend that all tickets are sold at official fares. Without abrogating IATA rules, Airlines cannot admit to any knowledge of agents' actual discounted selling prices. As a result, airlines do not usually know themselves, or would admit to knowing, by which agents or at what prices their tickets are most cheaply sold.

Following Lee and Luengo-Prado (2005), we estimate six ordinary least square (OLS) models for each of the six large network carriers as well as estimate a single pooled regression for all of the carriers. We estimate the following non-pooled equation with quarterly observations for the period 2006 Q3 – 2008 Q4 for each of our six carriers

$$\ln P_{jt} = \alpha + IGH_{jt}\beta + IGHR\kappa_{jt} + X_{jt}\delta + \varepsilon_{jt} \tag{1}$$

where $\ln P_{jt}$ is the natural log of the carrier's average price per hundred miles in market j at time t (where market is synonymous with the US Department of Transportation's OD1B Origin and Destination definition of market representing the origination and destination city-pair points on a domestic itinerary), α is a constant; IGH_{jt} is a matrix of international gateway hub to non-gateway hub route dummies for the non-gateway hub carrier (international gateway hubs include Chicago, Dallas and Miami (AA), New York and Houston (Continental or CO), Atlanta, Cincinnati and New York (DL), Detroit and Minneapolis (Northwest or NW), Chicago, Los Angeles, San Francisco and Washington (United or UA) and Charlotte and Philadelphia (US Air or US). Non-overseas gateway hubs included St Louis, (AA), Cleveland, (CO), SLC (DL), Memphis (NW), Denver (UA) and after the merger between US Air and America West, Las Vegas and Phoenix (US). The IGH dummy equals 1 if either end point of market j at time t is an IGH and 0 otherwise (for example, SLC to Atlanta equals 1 for the IGH_{jt} dummy variable since the market origination point is SLC, Delta's non-gateway hub and the destination point is Atlanta, Delta's international gateway hub). If international passengers ascribe IGHs with premium service, arbitrage influences would force domestic passengers to pay higher prices when using the IGHs. In such a case, we would expect β to be positive.

$IGHR_{jt}$ is a matrix of route dummies for the non-gateway hub carrier showing routes from a rival's international gateway hub to the non-gateway hub X_{jt}. The IGHR dummy equals one when one of the route endpoints is a competitor's international gateway hub and zero otherwise (for example, SLC to Chicago equals 1 since SLC is Delta's non-gateway hub and Chicago is both American and United Airlines international gateway hub). If one carrier is not subject to a rival's presence on a route and therefore surmises that carrying passengers to a competitor's hub is an effective way to raise rival's costs and increase its own profits (that is, the Norman paradigm), we would expect the estimated coefficient, κ, on the rival route dummy variable, IGHR to be positive. If there is parallel vertical integration on the route we would expect the estimated coefficient, κ, to be insignificant.

We want to determine if arbitrage influences airlines to jointly evaluate domestic pricing to international gateway hubs and international pricing through these inter-connection points. Moreover, we want to determine whether such an influence systematically results in higher or lower prices to domestic passengers traveling to either an airline's international overseas gateway hub from a non-overseas gateway hub. In other words, does the integrated firm treat the foregone upstream profit as a significant opportunity cost of winning a more profitable downstream sale?

As an illustration, we wish to determine if carriers such as Delta charge passengers a premium to fly to its own international overseas gateway city from its non-gateway hub (SLC-Atlanta) and/or a premium to fly to a competitor's international overseas gateway city (SLC-Chicago). If Delta believes that its own domestic and international travel, U1-D1, are strong complements than profits would be maximized when Delta recognizes that high domestic prices have an adverse effect on its international flights (the concept known as double marginalization). In such a case, Delta would charge passengers a discount to fly to its international overseas gateway city from its non-gateway hub. If Delta believes that domestic and independent travel is independent, Delta would charge a hub premium between gateway and non-gateway hubs where it has market power. Delta may also decide to charge a price for international travel that does not equal the sum of the prices for the domestic and international leg of the international flight. If Delta believes that it can effectively raise rivals' costs (there is no meaningful parallel vertical integration on the route), it will charge passengers a premium to fly to its rival's overseas gateway city.

From equation (1), ε_{jt} is a random error term assumed to be i.i.d. with mean zero and variance σ^2_ε and, X_{jt} includes a matrix of the following control variables:

Distance$_j$ (natural log of the non-stop distance between the two city-pair airports). Previous research shows that prices are strongly correlated with distance. We expect average price per mile to decline as trip distance increases since per mile costs for a given flight decline as distance increases (see Table 1 showing dramatic cost reductions between domestic and international flights operations as costs decline with distance).

Passengers$_{jt}$ (natural log of total market passengers carried by all airlines in market *j* in quarter *t*). The total number of passengers in a market provides market demand but it also is an indicator of market density. Greater market density allows airlines to achieve cost savings by achieving scale economies. We further eliminated markets in which the individual carrier had fewer than 9000 passengers during the observed quarter to ensure that the carrier would be able to use larger, more cost efficient aircraft. The number 9000 is roughly equivalent to the requirement that the airline serves 100 passengers daily. Owing to economies of scale, we expect this coefficient to be negative.

Share$_{jt}$ (market share) – The carrier's percentage share of origination and destination passengers in market *j* during quarter *t* in whole numbers. Our OLS estimation instrument for *share*$_{jt}$ is the carrier's market share in the quarter of the previous year. This approach was used by Lee and Luengo-Prado (2005) as an instrumental variable in order to avoid endogeneity between the current carrier's price and current level of demand. Based on previous research such as Lee and Luengo-Prado (2005) and Borenstein and Rose (1994), high market share for an airline conveys pricing power, so we expect the coefficient to be positive. However, our abbreviated sample of city pairs ensures that the carrier will have a relatively high market share since the flight originates or terminates at the carrier's non-overseas gateway hub. For example, Continental's average market share for each of the fourth quarters of 2006 and 2007 at its Cleveland hub was 64 and 72 per cent, respectively. Consequently, we do not expect this variable to have much additional explanatory power.

Jet fuel$_t$ (average price per gallon in dollars) – The carrier's cost per gallon of jet fuel on domestic flights as reported by the airlines to the Department of Transportation (DOT). This variable shows considerable quarter-to-quarter variation during the estimated period and represents a significant component of an airline's variable cost. Therefore, we expect the coefficient on this variable to be positive.

PassMix$_{jt}$ (passenger mix) – The percentage share of a carrier's passengers who paid three times the minimum average fare in market *j* during quarter *t* in whole numbers. Previous studies such as Lee and Luengo-Prado (2005) and Gerardi and Shapiro (2007) have found passenger mix significantly impacts average airfare in a market. In order to capture this influence, we included a variable calculated by the DOT that identifies the percentage of passengers that pay three times more than DOT's calculated minimum increment for the market. Business travelers are most likely to pay these high prices. Therefore, this variable provides an effective way to distinguish whether carriers carry a large percentage of business travelers between particular city pairs. We expect the estimated coefficient to be positive since a higher percentage of passengers paying more than three times the minimum should result in higher average fares.

Florida – A dummy variable that equals one when the route contains a route endpoint for Florida and zero otherwise. Florida is an area that has attracted many low cost carriers and we expect the estimated coefficient to be negative.

When we run the regressions, our model predominately evaluates city pairs that originate or terminate from each individual carrier's non-gateway hub. These non-gateway hubs are Denver (United), Cleveland (Continental), SLC (Delta), Memphis and Indianapolis (Northwest), St Louis (American) and Phoenix and Las Vegas (US Air).

Table 3 contains summary statistics of the data over the estimation period for the various carriers and for the pooled dataset. These statistics show the arithmetic mean, minimum and maximum values for each of the variables as well as the standard deviation for each variable.

OLS POOLED REGRESSION RESULTS

The results of our OLS regressions are shown in Table 4. Table 4 contains both the individual carrier results and the pooled regression results. In the pooled regression all our variables are statistically significant and all are consistent with our expectations. The residuals are normally distributed and tightly bunched around the regression line in a random manner. The international gateway dummy, IGH, is positive indicating that the airlines price flights between their non-gateway hub and their overseas gateway hubs at a premium as compared to comparable flights from their non-gateway hub to non-gateway cities. For example, United prices their flights from Denver to Los Angeles, Chicago, Seattle, San Francisco and Washington, DC (their overseas gateways) at a premium above flights from Denver to Pittsburgh and so on. The coefficient on the rival's international gateway dummy, IGHR, is positive indicating that the airlines price flights between their non-gateway hub and the rival's overseas gateway hub at a premium. The coefficient on jet fuel is positive and much more significant when the year 2008 is included. Jet fuel costs spiked dramatically in 2008 and this higher variability in the fuel costs resulted in upward adjustments in fares that were widely reported at the time. Distance and total passenger size are negatively correlated with pricing as cost economies of scale are observed. The coefficient on market share is very low and relatively insignificant.

There are some notable differences between the regressions run using individual carrier data. In some cases the IGH and IGHR coefficients

Table 3: Pooled data statistics (2031 observations)

	Minimum	*Maximum*	*Mean*	*SD*
Fare	$81.13	$441.00	$189.75	$58.06
Passengers	15 997	460 990	84 495	67 700
Distance	226	2381	1066	578
Jet Fuel	$1.75	$4.71	$2.51	$0.64
Pax3xMin	0	43	6	6
IGH Dummy	0	1	0.09	0.29
FL Dummy	0	1	0.12	0.32
IGHR Dummy	0	1	0.10	0.30
MS Lag	0	99	42	21
United (443 observations)				
Fare	$94.56	$382.00	$192.71	$44.51
Passengers	18 930	39 537	30 283	28 339
Distance	349	1754	981	379
IGH Dummy	0	1	0.11	0.32
IGHR Dummy	0	1	0.16	0.36
Continental (228 observations)				
Fare	$91.84	$317.46	$202.57	$53.69
Passengers	17 942	178 356	47 637	25 155
Distance	288	2161	1069.079	603.4932
IGH Dummy	0	1	0.11	0.32
IGHR Dummy	0	1	0.02	0.15
Delta (301 observations)				
Fare	$87.00	$415.00	$194.91	$74.95
Passengers	15 997	15 2025	55 212	32 444
Distance	291	2105	992	610
IGH Dummy	0	1	0.07	0.25
IGHR Dummy	0	1	0.14	0.34
Northwest (180 observations)				
Fare	$98.00	$441.00	$200.76	$62.03
Passengers	17 763	129 333	48 554	24 836
Distance	231	1944	966	484
IGH Dummy	0.00	1.00	0.11	0.31
IGHR Dummy	0.00	1.00	0.13	0.33
American (224 observations)				
Fare	$96.62	$383.00	$190.10	$53.31
Passengers	17 960	182 372	56 581	35 572
Distance	258	1736	955	427
IGH Dummy	0.00	1.00	0.18	0.38
IGHR Dummy	0.00	1.00	0.13	0.33
US AIR (701 observations)				
Fare	$81.13	$400.00	$180.77	$58.14
Passengers	19 393	460 990	117 235	81 258
Distance	226	2381	1219	684
IGH Dummy	0.00	1.00	0.06	0.23
IGHR Dummy	0.00	1.00	0.04	0.20

are quite low and are statistically insignificant from zero.

So as to tie the model back to the Norman paradigm, we must provide a meaningful context to our regression results, that is, we must convert the model coefficients to price premiums. We provide several examples of how we used the model results to calculate price premium percentages.

For example, in order to calculate the United Airlines price premium for its own overseas gateway hub, we determine the prediction for the dependent average price variable, ln price per 100 miles, for United Airlines' 1024 mile flight from Denver to Seattle during the fourth quarter of 2006 that is consistent with the model results reported in Table 4. The model's predicted value is equal to 3.057826 ($6.984 - 0.515 \times$ ln distance $- 0.13 \times$ ln fourth quarter total passengers $+ 0 \times$ lagged market share in fourth quarter $2005 + 0.049 \times$ fourth quarter 2006 Jet Fuel price $- 0.219 \times$ Florida Dummy Variable $+ 0.066 \times$ IGHR Dummy Variable $+ 0.175 \times$ IGF Dummy Variable $+ 0 \times$ fourth quarter 2006 Passenger Mix).

Without the IGH Dummy, ($0.175 \times$ IGH Dummy Variable), the model's predicted value would be 2.882826. In other words, if Seattle had not been a United Airlines overseas gateway city, the natural log would have been considerably lower. As the model's average price values are in natural log form, we must convert the model's predicted values to dollars and cents. Converting the natural logs into dollars and cents we get an average price of \$218 (\$21.28 per 100 miles $\times$ 10.24) for the United Airlines fourth quarter flight from Denver to Seattle. If Seattle had not been a United Airlines overseas gateway hub the model predicted the flight would have been only \$183 (\$17.86 per 100 miles $\times$ 10.24). The \$35 price differential associated with flying to the hub is equivalent to a 16.1 per cent price premium (\$35/\$218).

As an example of the calculation of the price premium for a rival's gateway hub, we determine the Table 4 model prediction for the

Table 4: OLS regression results

OLS	*United*	*Continental*	*Delta*	*Northwest*	*American*	*US Air*	*All*
Constant	6.984* (0.125)	8.336* (0.152)	7.134* (0.166)	9.704* (0.218)	7.419* (0.194)	7.553* (0.076)	7.653* (0.052)
Distance	−0.515* (0.017)	−0.727* (0.017)	−0.577* (0.020)	−0.911* (0.029)	−0.689* (0.025)	−0.654* (0.008)	−0.657* (0.006)
Passengers	−0.130* (0.011)	−0.169* (0.022)	−0.089* (0.016)	−0.201* (0.025)	−0.026* (0.031)	−0.074* (0.008)	−0.101* (0.006)
Lag MS	0.000 (0.000)	0.002 (0.000)	0.002* (0.000)	0.004* (0.000)	0.002* (0.001)	0.001 (0.000)	0.001* (0.000)
Jet Fuel	0.049* (0.009)	0.052* (0.016)	−0.004 (0.016)	0.034* (0.012)	0.079* (0.021)	0.031* (0.007)	0.033* (0.005)
Fl Dummy	−0.219* (0.025)	−0.104* (0.023)	0.005 (0.043)	−0.254* (0.034)	−0.178* (0.026)	−0.065* (0.017)	−0.130* (0.011)
IGHR Dummy	0.066* (0.019)	0.425* (0.068)	−0.027 (0.029)	−0.054 (0.040)	0.106* (0.038)	0.007 (0.023)	0.094* (0.012)
IGH Dummy	0.175* (0.023)	0.190* (0.035)	0.190* (0.053)	0.074 (0.046)	−0.209* (0.031)	0.064* (0.021)	0.077* (0.013)
Pass 3X	0.000 (0.001)	0.010* (0.001)	0.020* (0.002)	0.013* (0.002)	0.017* (0.002)	0.016* (0.001)	0.015* (0.001)
Adj. R^2	0.810	0.933	0.819	0.940	0.864	0.931	0.871
N	443	228	301	180	224	700	2030
Non-IGH hubs	Denver	Cleveland	Salt Lake City	Memphis, Indianapolis	St. Louis	Phoenix, Las Vegas	

*Significant at 5 per cent level.

dependent average price variable, ln price per 100 miles, for United Airlines' 680 mile flight from Denver to Minneapolis during the fourth quarter of 2006 is equal to 3.139548 ($6.984-0.515 \times$ ln distance $-0.13 \times$ ln fourth quarter total passengers $+ 0 \times$ lagged market share in fourth quarter $2005 + 0.049 \times$ fourth quarter 2006 Jet Fuel price $-0.219 \times$ Florida Dummy Variable $+ 0.066 \times$ IGHR Dummy Variable $+ 0.175 \times$ IGF Dummy Variable $+ 0 \times$ fourth quarter 2006 Passenger Mix). Minneapolis is a gateway hub for Northwest Airlines, a rival to United Airlines on Pacific routes.

Without the IGHR Dummy, ($0.066 \times$ IGHR Dummy Variable), the model's predicted value is 3.073548. As the model's average price values are in natural log form, we must convert the model's predicted values to dollars and cents. Converting the natural logs into dollars and cents we get an average price of \$157 (\$23.09 per 100 miles $\times$ 6.8) for the United Airlines fourth quarter flight from Denver to Minneapolis. If Minneapolis had not been a Northwest Airlines hub the model predicted the flight would have been only \$147 (\$21.62 per 100 miles $\times$ 6.8). The \$10 price differential is equivalent to a 6.4 per cent price premium (\$10/\$157). The price premium results for all the airlines are shown below:

	IGH premium (%)	*IGHR premium (%)*
United	16.1	6.4
Continental	17.3	34.6
Delta	17.3	−2.7
Northwest	7.1	−5.5
American	−23.2	10.0
US Air	6.2	0.7
Pooled	7.4	9.0

United, Continental and Delta charge a considerably higher IGH premium than any of the other carriers. In addition, Continental charges the highest IGHR premium. American charges considerably less to fly to its IGH hubs. When American flies from St Louis to New York, Miami, Dallas or Chicago (that is, international gateway cities), rates are discounted. A closer examination of the data shows that American routes flights to South American sparingly through Miami and Dallas. American flights to Europe and Asia are routed through Chicago and New York. Low rates from St Louis are available on the Miami and Dallas routes but not on the Chicago and New York routes. Therefore, we believe that the American discount anomaly exists only for its secondary international gateway hubs.

When the results are pooled, airline carriers charge a 7.4 per cent premium to fly to their gateway hubs and a 9 per cent premium to fly to a rival's gateway hub.

APPLICATION OF NORMANN PARADIGM TO DATASET

A more extensive analysis on the IGHR premium for each carrier was conducted in order to why some carriers increase prices on their major rival's international gateway routes and others do not. As shown in the Normann paper, when a carrier face parallel integration on routes served by their major rivals, there is little ability to raise rival's costs. On routes where a carrier does not face parallel integration, profit-maximizing behavior dictates that the carrier would charge higher prices in order to raise its rival's costs.

Let's initially consider two actual examples of upstream and downstream firms from our dataset and apply Normann's paradigm described above. The first example shows where the raising rivals cost strategy could be a profit-maximizing strategy since only one firm is vertically integrated. The second example shows where the raising rivals cost strategy would likely be ineffective since both the rival firms are vertically integrated.

In example 1, a passenger is flying between St Louis (STL) and Paris. The two firms in our example are American (AA) and United Airlines (UA). American's composite good, U1-D1 is made up of the domestic segment between STL and Chicago, U1 and the overseas segment between Chicago and Paris, D1. American offers its own input good, U12 which United could combine with its downstream good, D2 made up of the domestic segment between STL and Chicago, U12 and the international segment, Chicago to Paris, D2 (that is, the shortest route with the fewest stops from St Louis to Paris will be through UA's international gateway hub at O'Hare Airport). UA only flies a direct route from St Louis to Denver, U2. St Louis passengers that want to fly to Paris can also do so by buying the composite good, U1-D2, where U1 is the American flight between St Louis and Chicago and D2 is the United Airlines flight between Chicago and Paris.

One approach that AA could take to blunt UA's competition is to raise its rival's costs by its own component pricing decisions. In this example, United Airlines is only competing in the downstream market, so AA need only consider the opportunity cost of charging a high price for a flight from St Louis to Chicago to its domestic only customers against the additional profit that could be earned from adding more customers on its own downstream leg from the Chicago Airport to Paris.

In our *parallel* vertical integration example 2, a passenger is flying between SLC and Paris. The two firms in the second example are Delta (DL) and AA. Delta's composite good, U1-D1 is made up of the domestic segment between SLC and New York, U1 and the overseas segment between New York and Paris, D1 (that is, the shortest route between SLC and Paris). Delta also flies to Europe from Atlanta but for simplicity we will focus only on overseas routing through JFK. American offers its own composite good, U2-D2 which is made up of the domestic segment between SLC and Chicago, U2 and the international segment, Chicago to Paris, D2 (that is, the shortest route with the fewest stops from SLC to Paris will be through AA's international gateway hub at Chicago). SLC passengers that want to fly to Paris can do so by buying the composite good, U12-D2, where U12 is the Delta flight between SLC and Chicago and D2 is the AA flight between Chicago and Paris. Delta offers a compatible component product, U12 that can be used by AA to produce a composite good, U12-D2 that directly competes with Delta's own composite good, U1-D1. AA does *not* offer a compatible product U21, a direct flight between SLC and New York's JFK that can be used by Delta to produce a composite good U21-D1 (where D1 is a DL flight from JFK to Paris). One approach that DL could take to blunt AA's competition is to try to raise its rival's costs by its own component pricing decisions. However, AA has an alternative to Delta's component since AA is vertically integrated on the SLC to Paris route. If Delta raises the c2 price of its component from SLC to Chicago, U12, AA can use its own upstream component from SLC to Chicago, U2.

For three of the carriers, United, Continental and American, the OLS regressions resulted in a significant coefficient for the IGHR variable. For the remaining three carriers, Delta, Northwest and US Air the coefficients on the IGHR variable were insignificant. Do United, Continental and American fly routes vital to their rivals where they have significant market power while Delta, Northwest and US Air do not?

Table 5 displays an evaluation for each of the city-pair routes in our study that were characterized by the IGHR dummy. On the left-hand side we show for the carriers that had a significant IGHR variable each of their specific IGHR routes and any comparable routes of their rivals. On the right-hand side, we show for carriers that had an insignificant IGHR variable each of their specific IGHR routes and any comparable routes of their rivals. We also identify whether the carrier had market power on the route or not, based on whether carriers face parallel integration (that is, comparable routes of their rivals) or not. When there is market power, we expect a

Table 5: Extent of vertical integration on rival's routes market

Carrier	City-pair route	Market share (%)
United	Denver/Chicago	37
American	Denver/Chicago	22
United	Denver/Detroit	17
Northwest	Denver/Detroit	44
United	Denver/Los Angeles	43
American	Denver/Los Angeles	15
United	Denver/Minneapolis	26
Northwest	Denver/Minneapolis	49
United	Denver/New York LGA	43
Continental	Denver/New York EWR	18
United	Denver/Philadelphia	35
US AIR	Denver/Philadelphia	28
United	Denver/San Francisco	56
United	Seattle	45
United	*Significant IGHR variable*	
Major rivals NW/AA Pacific routes		
Continental	CLE/PHL	44
US Air	CLE/PHL	51
Continental	CLE/Washington	78
United	CLE/Washington	19
Continental	*Significant IGHR variable*	
Major rivals DL/AA Atlantic routes		
American	St Louis/Atlanta	25
Delta	St Louis/Atlanta	41
American	St Louis/Chicago	43
American	St Louis/New York	82
CO	St Louis/New York	45
American significant IGHR variable		
Major rivals DL/CO Atlantic routes		
Northwest/UA Pacific routes		
Delta	SLC/CHI	35
American	SLC/CHI	20
United	SLC/CHI	18
Delta	SLC/EWR	68
CO	SLC/EWR	21
Delta	SLC/Philadelphia	58
Delta	SLC/Washington	55
United	SLC/Washington	11
Delta	*Insignificant IGHR variable*	
Major rivals AA/CO Atlantic routes		
NW	Indianapolis/NY LGA	24
US	Indianapolis/NY LGA	34
CO	Indianapolis/NY EWR	25
NW	Memphis/Atlanta	17
DL	Memphis/Atlanta	44
Northwest	*Insignificant IGHR variable*	
Major rivals United/AA Pacific routes		
US AIR	Las Vegas/Chicago	14
AA	Las Vegas/Chicago	16
United	Las Vegas/Chicago	25
US Air	Las Vegas/Detroit	12
NW	Las Vegas/Detroit	54
US Air	Phoenix/Dallas	34
AA	Phoenix/Dallas	51
US Air	*Insignificant IGHR variable*	
All are rivals – Weak competitor		

Substantial Market Power on Rival's Route.
Rival has some pressence on route.
Code sharing leads to market power.

significant IGHR dummy. Consequently, the left hand side carriers should face very limited parallel integration of their IGHR routes.

United Airlines specializes in Pacific route destinations, as previously shown in Table 2. The major Pacific route international gateway hubs from Denver are Los Angeles and San Francisco for United Airlines and its major rivals. Northwest does not fly from Denver to either city and American only flies to Los Angeles. However, American has a relatively small share of the Los Angeles market. Since United did not face parallel integration from Northwest and faced only limited parallel integration from American, United could increase its rivals' costs by keeping its prices high. The Normann paradigm is consistent with United's pricing on its Pacific routes. United confronted significant competition on Atlantic routes since Chicago is the major Atlantic route international gateway hub from Denver.

Continental specialized in Atlantic route destinations as shown in Table 2. The rival routes that we examined were through Philadelphia and Washington. Continental dominated the Washington route although United did have small commuter flights from Cleveland to Washington (less than 100 passengers per day). During most of the study period Continental, US Air and United did not fly these routes. These routes only were flown during 2006 Q4 – 2007 Q2. Although Continental kept its prices high, apparently the passenger flow was low and all the airlines dropped the flights.

The final carrier that had a significant IGHR variable was AA. AA was the largest international overseas carrier during our study period, flying predominately Atlantic routes and one Pacific route to Tokyo. The best international gateway hub from St Louis would be either Chicago or New York. American was the only carrier flying from St Louis to Chicago. As American did not face parallel integration on this route and only limited parallel integration from Continental on its New York JFK route (Continental does not fly from Kennedy Airport but instead flies from Newark making the connection for an international flight very difficult), American can increase its rivals' costs by keeping its prices high. The Normann paradigm is consistent with American's pricing on its Atlantic and Pacific routes.

The three carriers that did not have significant coefficients on their IGHR variables also faced parallel integration on their routes to and from their rivals' major international gateway hubs. With the exception of some Delta routes, all of the results are consistent with the Normann paradigm since parallel vertical integration was usually in evidence. For example, Delta faced parallel integration from one of its major rivals, American on its flights from SLC to Chicago. Northwest faced parallel integration on routes from Memphis to Atlanta from Delta and US Air faced parallel integration from Northwest on flights from Las Vegas to Detroit.

Yet on several Delta routes the results are inconsistent with the Normann paradigm. Delta was the only carrier flying from SLC to Philadelphia, US Air's international gateway hub. Therefore, Delta had the ability to raise the costs of US Air. However, US Air was a relatively weak competitor for international overseas passengers. Delta also dominated the Washington route as United operated small commuter flights from SLC to Washington (less than 100 passengers per day). Therefore, Delta had the ability to raise the costs of United for flights to Washington, but not for flights to Chicago. As previously discussed, United Airlines was not Delta's major rival on Atlantic routes (Table 5).

EVALUATION OF INTERNATIONAL PRICING DATA

As airlines have the ability to charge a lower rate for a direct international flight than for a comparable flight comprised of each separate leg of the flight, we evaluated whether arbitrageurs impacted this ability. The pricing data that we collected were offered prices for 2009 flights to Rome, Tokyo and Hong Kong shown on airline reservation websites or Bing.com. Although the data are outside our sample period, we did compare the percentage premiums rather than the actual dollar fare for our study data and the 2009 data. The international flights originated in the non-gateway hub city, of the individual carrier and terminated in one of the three foreign destinations. As shown in Table 6, prices on direct flights are consistently lower than those offered on each leg of the trip. Hong Kong routes are generally exempt from this pattern. Delta charged the lowest price on its direct flights from SLC relative to the charges for its domestic and international legs. Continental's prices were the most similar for direct flights and flights comprised of the sum of the legs. American charges are route sensitive, since it charges both high (Tokyo) and low (Hong Kong) prices on its direct flights relative to its prices for each leg segment.

Table 6: International pricing data

Date	Carrier	Route	Direct ($)	Sum of legs $	Difference $	Difference (%)
Rome flights						
8-25-9-1	American	STL-ORD-FCO	1080	1144	64	5.6
10-13-10-20	American	STL-ORD-FCO	778	895	117	13.1
8-25-9-1	Continental	CLE-EWR-FCO	1304	1359	55	4.0
10-13-10-20	Continental	CLE-EWR-FCO	1151	1172	21	1.8
8-25-9-1	Delta	SLC-JFK-FCO	794	957	163	17.0
8-25-9-1	Delta	SLC-ATL-FCO	1186	1110	−76	−6.8
10-13-10-20	Delta	SLC-JFK-FCO	881	1019	138	13.5
10-13-10-20	Delta	SLC-ATL-FCO	1183	1414	231	16.3
8-25-9-1	United	DEN-IAD-FCO	1378	1514	136	9.0
10-13-10-20	United	DEN-IAD-FCO	824	978	154	15.7
8-25-9-1	US Air	LV-PH-FCO	836	873	37	4.2
10-13-10-20	US Air	LV-PH-FCO	893	1053	160	15.2
Northwest does not fly from Indianapolis or Memphis to Rome						
Tokyo and Hong Kong flights						
8-25-9-1	American	STL-LAX-HGK	2061	2082	21	1.0
8-25-9-1	American	STL-LAX-NRT	1122	1448	326	22.5
8-25-9-1	Continental	CLE-IAH-NRT	939	1026	87	8.5
8-25-9-1	Northwest	MEM-MSP-NRT	1118	1487	369	24.8
8-25-9-1	United	DEN-SFO-HGK	1012	1067	55	5.2
10-13-10-20	American	STL-LAX-HGK	1438	1461	23	1.6
10-13-10-20	American	STL-LAX-NRT	867	977	110	11.3
10-13-10-20	Continental	CLE-IAH-NRT	991	1071	80	7.5
10-13-10-20	Delta	MEM-MSP-NRT	990	1205	215	17.8
10-13-10-20	United	DEN-SFO-HGK	1207	1223	16	1.3

8/25 Flights based on 27 July 2009 listings on Airline websites and Bing.com.
10/13 Flights based on 27 August 2009 listings on Bing.com and Airline websites.

DIFFERENTIAL PRICING AT PRIMARY AND SECONDARY HUBS

We wanted to determine if the carriers regard their primary international gateway hubs differently from non-gateway hubs. Do they charge a higher percentage premium to fly between primary international gateway hubs than between a non-gateway hub and an international gateway hub? For example, does United charge a higher premium to fly between its primary international gateway hubs, Chicago and Washington, DC than between Denver and Chicago? Does Continental charge more to fly between its primary gateway hubs, New York and Houston, than between Cleveland and Houston? In order to answer these questions, we eliminated the non-gateway hub to international gateway hub route observations used in our previous pooled regression as the IGH dummy variable. In place of the eliminated observations, we substituted international gateway hub to international gateway hub routes, for example, Delta's Atlanta to New York city pair constitutes such a route). These new IGH-to-IGH route observations became the new 'IGH' dummy variable. We then re-ran the regressions using the identical structure. Table 7 provides a comparison of this new 'IGH'

Table 7: Regression comparison of hubbing structure pricing

OLS regressions	*Preferred data set excluding IGH to IGH routes*		*IGH to IGH routes only*	
	Coefficient	*SD*	*Coefficient*	*SD*
Constant	7.652	−0.052	7.585	0.052
Distance	−0.657	−0.006	−0.651	0.006
Passengers	−0.1	−0.005	−0.092	0.005
Lag MS	0.001	0	0.001	0.000
Jet Fuel	0.033	0.005	0.034	0.005
FL Dummy	−0.13	0.011	−0.138	0.011
IGHR Dummy	0.094	0.012	0.100	0.013
IGH Dummy	0.076	0.013	0.244	0.018
Pass 3X	0.015	0.001	0.013	0.001
Adj. R^2	0.871	—	0.867	—
N	2031	—	1962	—

All coefficients are significantly different from zero at 5 per cent level.

pooled regression with the previous pooled regression shown in Table 4. The comparison results show that the IGH coefficient increased substantially in the new 'IGH' pooled regression. The 7.4 per cent price premium reported in Table 4 increased to 21.7 per cent in the new IGH to IGH-only regression. Clearly airlines price flights between their gateway hubs much higher than flights between a non-gateway hub and a gateway hub.

CONCLUDING REMARKS

The results are generally consistent with our belief that most airlines would charge a premium to international gateway cities. International passengers pay considerably more for airfare than domestic passengers and we believe international passengers are less price sensitive. International passengers generally have higher income than domestic passengers and/or are flying for business purposes. We also found that when parallel vertical integration is absent, most airlines do seek to raise their rivals' costs by charging a higher price to fly to a rival's IGH.

The international pricing results also imply that arbitrageurs have not been fully effective on all airline routes. Flights to Hong Kong are priced similarly when we compare direct flight prices from non-gateway hubs to piece-wise prices for each leg of the trip. However, large pricing differentials can exist on other routes such as Rome and Tokyo. These large differentials offer an alternative explanation as to why airlines charge a premium to international gateway cities. Airlines can choose to segregate their domestic and international markets and offer lower prices on direct international flights to passengers who originate these international flights from non-gateway hubs.

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Research Article

Revenue management in the car rental industry: A stochastic programming approach

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Alwin Haensel, Michael Mederer and Henning Schmidt
Department of Mathematics, VU University Amsterdam, Amsterdam, the Netherlands

Alwin Haenselis a doctoral candidate at the VU University Amsterdam. He received his Master's degree in Mathematics at the Humboldt University of Berlin on Stochastic Programming. During his study he worked at the revenue management department of Avis Europe Plc. His research focuses on revenue management and demand forecasting.

Michael Mederer is currently a senior operations research consultant and founder of the operations research consultancy m2-hycon. He has a PhD from Clausthal University of Technology and has been teaching Operations Research, Stochastics and Applied Mathematics for several years. His working experiences and major research interests include a broad variety of subjects in the field of Airline Operations, Transportation, Revenue Management, Queuing Theory and Supply Chain Management.

Henning Schmidt has developed and researched forecasting and optimization methods in car rental context at Avis Europe Plc. The focus has been on modeling flexible capacities in revenue management. He received a PhD from Clausthal University of Technology and his research interests include queuing theory and stochastic simulation.

Correspondence: Alwin Haensel, Department of Mathematics, VU University Amsterdam, 1081 HV, Amsterdam, The Netherlands
E-mail: a.haensel@vu.nl

ABSTRACT A stochastic programming approach for a network revenue management problem with flexible capacities is presented. The study focuses on a car rental network, which has the special property that the fleet distribution between rental stations in the network can easily be adjusted at determined costs. Our method simultaneously optimizes the fleet distribution on the network and the capacity controls at station level. A two-stage stochastic program is considered, where the demand uncertainty in the second stage is approximated by a finite number of scenarios. The performance of the proposed stochastic method is tested by simulation on a small car rental network and compared with the results of a deterministic program.

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INTRODUCTION

Capacity controls are the classical tool in revenue management (RM) problems, where the seller of a perishable product tries to maximize revenue by smart control actions during the booking process. The origin of RM lies in airline industry. It started in the 1970s and 1980s with the deregulation of the market in the United States. The initial approach is given by Littlewood (2005[1972]), he proposes an optimal decision rule for the case of selling two price classes, which arrive in the order low before high. Belobaba (1989) extended this approach with the (expected marginal seat revenue) heuristics for the case of multiple independent products. The next step was the move from leg based optimization to the origin, destination and fare class (ODF) optimization on the total airline network. A brief introduction to some basic models is given in Talluri and Van Ryzin (2004). The first approach works with deterministic demand as input to a linear program. Further approaches try to incorporate the stochastic nature of the demand and are given by Wollmer (1992) or Talluri and Van Ryzin (1998). Williamson (1992) finds that often probabilistic approaches are outperformed by the deterministic, but De Boer *et al* (2002) show that this is owing to the lack of nesting of fare classes in the booking process. The overview is concluded with the multi-stage stochastic programming approach for the network RM problem proposed by Möller *et al* (2008), which considers a stochastic demand and cancellation process on an ODF network. An advanced scenario tree generation method is used, which reduces the number of instances from the initial scenario sample, to downsize the problem dimension.

In this article, we study the network RM problem with flexible capacities. We work in the car rental context, where cars can be transfered between rental stations. Similar problems occur, for example, in the airline industry when airplanes with different sizes can be swapped between legs of the network (see Frank *et al*, 2006; Haensel, 2008), or in cargo logistics when multiple and/or different vehicles can be assigned to routes. As shown in the PhD thesis of Schmidt (2009), the control process is a Markov Decision Problem and the optimal controls can not be computed exactly. We propose a two-stage stochastic programming model, which considers multiple rental lengths on one car type. The basic stochastic model is adapted from Möller *et al* (2008) and extended with the concept of variable capacity, similarly to Haensel (2008). We describe a two-stage problem with the total future uncertainty in the second stage and hence the stochastic demand process is approximated by a fan shaped scenario tree.

The article continues in the following section with the explanation of the car rental RM problem, followed by the description of the proposed stochastic programming model in the subsequent section. Finally, we present the numerical results in the penultimate section and conclude our findings in the final section.

CAR RENTAL RM PROBLEM

The first report of a RM application to car rental is found in Carroll and Grimes (1995), who describe the RM system implemented in 1990 and 1991 at Hertz. They report an average revenue increase per rental of 1–5 per cent. An other success story is reported by Geraghty and Johnson (1997), who describe the RM system implemented in 1993 and 1994 at National Car Rental. Their system focuses more on pricing and capacity control at station level, where in contrast Carroll and Grimes (1995) emphasizes the total fleet control and distribution of the network. The RM problem of an individual car rental station is similar to the hotel RM problem. In the hotel context, we consider room nights as capacities and the products are combinations of price classes, arrival day and length of stay. In the car rental setting, the capacities are the available days of cars and the length of rental (LoR) is the equivalent to the length of stay. The difference arises when we consider the network case. The hotel chain cannot move rooms between different locations or easily build new rooms, to adjust the capacity. In contrast, within a car rental network we can transfer cars between different rental stations at very moderate costs. Also the total fleet can be adjusted to different market conditions by buying or selling cars. The possibility of controlling the flexible fleet is the major difference of the car rental problem to other RM settings.

This article combines classical RM and the optimal fleet distribution within the network. The decisions on the total fleet number are long-term questions and in reality also depend on market situations, as well as on contracts with car manufacturers and are not considered in this article.

Each car in the network is always assigned to a rental station and it can be in two states, either on-rent or idle. We will consider one car type and at most one rental per car per day, that is, the granularity are full rental days. Each car is picked up in the morning and returned in the evening, such that a car can be returned and newly rented the next day. We will neglect cancellations and late returns, which would have to be considered in practice.

STOCHASTIC PROGRAMMING MODEL

In this chapter, we describe the stochastic RM model. The model comprises all rental products of the network and their demand for a certain time period. As we want to maximize the generated revenue for the whole rental network, an optimal control for a single rental station does not necessarily lead to a optimal revenue for the whole network. Rental requests will be accepted as long as the booking limit for the product is not reached. Later, we will extend this approach with our concept of variable capacity, where the optimal booking limits are simultaneously computed with the optimal fleet distributions on the rental network. Cars can be moved between rental stations to given transfer costs. In the model, we will only consider one car type and hence the products are combinations of rental station, pickup day and the LoR. As resources we consider possible rental days of cars at all stations, that is, a two day rental (LoR 2) at station r utilizes two resources of station r.

Notation

R	set of rental stations in the network
D	set of consecutive pickup days to be considered in the model
L	set of possible LoR
P	set of products (pickup day, station and LoR combinations)
$A\in\mathbb{R}^{\lvert R\rvert \times \lvert P\rvert}$	denotes the *resource-product-matrix* ($a_{i,j}$ equals one if the jth product utilizes the ith resource and otherwise zero)
$p\in\mathbb{R}^{\lvert P\rvert}$	denotes the price vector (prices for each product)
$d\in\mathbb{N}^{\lvert P\rvert}$	denotes the random demand vector
$u\in\mathbb{Z}^{\lvert P\rvert}$	denotes the booking limit for each product
$cap\in\mathbb{N}^{\lvert R\rvert}$	denotes the fleet capacity at rental stations

The demand observation is a realization of a discrete time stochastic process on a probability space $(\Omega, \mathcal{F}, P)$. The task is to determine booking limits u such that the expected revenue is maximized:

$$\text{maximize} \quad \mathbb{E}\left[p^T b\right], \tag{1}$$

where $b\in\mathbb{Z}^{\lvert P\rvert}$ denotes the number of bookings, which obviously depends on the passenger demand and on the booking limits. This leads to the constraint

$$b = \min\{u,\ d\}. \tag{2}$$

Further more, the bookings and booking limits have to satisfy the conditions: non-negativity and integrality

$$b,\ u \geqslant 0, \tag{3}$$

$$b,\ u \in \mathbb{Z}^{\lvert P\rvert}. \tag{4}$$

In order to achieve reasonably fast computation times when using standard Mix Integer Problem (MIP) solving methods, we linearize the minimum condition in (2) by introducing additional variables $z_b, z_d\in\mathbb{R}^{\lvert P\rvert}$ and $z\in\{0,1\}^{\lvert P\rvert}$ with the following constraints

$$b + z_b = u, \tag{5}$$

$$b + z_d = d, \tag{6}$$

$$0 \leqslant z_b \leqslant (1-z)\kappa, \tag{7}$$

$$0 \leqslant z_d \leqslant z \cdot d, \tag{8}$$

where κ is a sufficiently large positive constant.

The fleet capacity per station is not fixed and can vary from day to day. Every car in the network is assigned to one station and can either be on-rent or idle. With over night transfers, cars can be moved between stations in the network at given transfer costs. For the car transfer decisions between the rental stations, we introduce additional decision variables $x \in \mathbb{Z}^{|D| \times |R| \times |R|}$. The value $x_{t,q,r} = k$ is interpreted as the decision to transfer k cars from station q to station r in the night between day $t-1$ and t. Note that $x_{t,r,r}$ denotes the number of cars staying at station r. The capacity for each station r at each day t is given by $\sum_{q \in R} x_{t,q,r}$, the sum of all cars which are transfered into station r or staying at station r. The following constraints are added to keep a constant fleet size. For every station $i \in R$, it has to hold that

$$\begin{aligned} &\sum_{r \in R} x_{1,i,r} = cap_i, \\ &\sum_{r \in R} x_{t,i,r} = cap_i + \sum_{\tau=1}^{t} \left(\sum_{q_1 \in R} x_{\tau,q_1,i} - \sum_{q_2 \in R} x_{\tau,i,q_2} \right), \\ &\qquad \forall t \in D \backslash \{1\}. \end{aligned} \tag{9}$$

We introduce a time function $\mathcal{T}$, which returns the used time period of a related rental product, that is, the pickup and on-rent days. For example, $\mathcal{T}(u(i)) = \{t\}$ means that product i is a 1-day rental (LoR 1) with pickup day t. $\mathcal{T}(u(j)) = \{t, t+1, t+2\}$ describes a three day rental with pickup at day t. The variables: u and b are defined as arguments for function $\mathcal{T}$. Furthermore, an indicator function $\mathcal{I}_t(\cdot)$ also defined on the product instance variables (u and b) is given by

$$\mathcal{I}_t(u(i)) = \begin{cases} u(i) & \text{if } t \in \mathcal{T}(u(i)) \\ 0 & \text{else} \end{cases}. \tag{10}$$

The indicator function is used to link products and resources over time. Obviously, the booking limits for future products have to be restricted by the actual total available capacity subtracted the previous rentals, which are on-rent and not returned to the station yet. The general relationship is

$$\text{pickup} + \text{on-rent} \leqslant \text{capacity of station.}$$

More formalized, the constraint takes the following form

$$\begin{aligned} &\sum_{l \in L} u_{t,i,l} + \sum_{k \in L \backslash \{1\}} u_{t-k+1,i,k} \leqslant \sum_{q \in R} x_{t,q,i}, \\ &\qquad \forall i \in R,\ \forall t \in D, \end{aligned} \tag{11}$$

where $u_{d,\cdot,\cdot} = 0$ for all $d \leqslant 0$ represents an initial state of the system where all cars are idle. One can also choose to start with a loaded system where the fraction of on-rent cars is represented by non-zero historical booking limits. Using the indicator function we can rewrite (11) to

$$\begin{aligned} &A_{(i,.)} \cdot \mathcal{I}_t(u) \leqslant \sum_{q \in R} x_{t,q,i}, \\ &\forall i \in R,\ \forall t \in D. \end{aligned} \tag{12}$$

Transfer costs between stations are defined by

$$\begin{aligned} TC(q, r) = &\text{cost of transferring one car} \\ &\text{from stations } q \text{ to station } r. \end{aligned}$$

The aggregated transfer costs have to be subtracted from the total revenue. Naturally, a non-transfer decision $x_{t,r,r} > 0$ comprises a cost of zero, that is, $TC(r, r) = 0$ for all stations r. We further assume that the transfer costs satisfy the triangle inequality, that is, for any three stations a, b and c we have $TC(a, b) + TC(b, c) > TC(a, c)$.

We consider a two-stage stochastic recourse model, see Ruszczyński and Shapiro (2003), where the demand uncertainty is contained in the second stage and the problem is solved for the total pickup period D at once. The first-stage solution is used to control the booking process and the fleet distribution across the network. The random demand process is approximated by a finite sample S of demand scenarios d_s with probabilities π_s for all $s \in S$, with $\sum_{s \in S} \pi_s = 1$. The complete stochastic integer program (SIP) looks as

objective function

$$\text{maximize} \sum_{s \in S} \pi_s \left(p^T b_s\right) - \sum_{t \in D} \sum_{q,\, r \in R} x_{t,q,r} TC(q,\, r) \tag{14}$$

subject to

- with (5)–(8) it follows $\forall s \in S$ and κ sufficiently large:

$$b_s + z_{b,s} = u$$

$$b_s + z_{d,s} = d_s$$

$$0 \leqslant z_{d,s} \leqslant z_s d_s \qquad 0 \leqslant z_{b,s} \leqslant (1 - z_s)\kappa$$

- condition of constant fleet size on transfer decisions (9):

$$\sum_{r \in R} x_{1,i,r} = cap_i, \qquad \forall i \in R$$

$$\sum_{r \in R} x_{t,i,r} = cap_i + \sum_{\tau=1}^{t} \left(\sum_{q_1 \in R} x_{\tau,q_1,i} - \sum_{q_2 \in R} x_{\tau,i,q_2} \right), \quad \forall i \in R,\ \forall t \in D \backslash \{1\}$$

$$x_{t,q,r} \geq 0, \quad x_{t,q,r} \in \mathbb{Z}, \quad \forall q,\ r \in R,\ \forall t \in D$$

- capacity limits with indicator function (12), $\forall t \in D$:

$$A_{(i,.)} \cdot \mathcal{I}_t(u) \leqslant \sum_{q \in R} x_{t,q,i}, \qquad \forall i \in R$$

- integrality and non-negativity, for $s \in S$:

$$u,\ b_s \in \mathbb{Z}^{|P|}$$

$$u,\ b_s \geqslant 0 \text{ and } z_s \in \{0,\ 1\}^{|P|}$$

Over all, we have a large mixed-integer linear program of the following dimension:

- continuous variables (z_b, z_d): $2 \cdot |P| \cdot |S|$
- integer variables (b, u, x): $|P| \cdot |S| + |P| + |D| \cdot |R|^2$
- binary variables (z): $|P| \cdot |S|$
- constraints: $5 \cdot |P| \cdot |S| + |P| + |D| \cdot (2 \cdot |R| + |R|^2)$

We will compare the results of the stochastic program with our extension of the deterministic linear program, described in Talluri and Van Ryzin (2004) and Geraghty and Johnson (1997). The deterministic linear program is a standard network model in literature and industry. Owing to the integrality condition, we will further refer to it as the deterministic integer program (DIP). The DIP maximizes the total revenue based on the expected demand $E[d]$:

$$\begin{aligned} &\text{maximize } p^T u \\ &\text{s.t.} \quad 0 \leqslant u \leqslant E[d], \\ &\qquad A u \leqslant cap, \\ &\qquad u \in \mathbb{Z}^{|P|}. \end{aligned} \tag{15}$$

Including the transfer decision leads to the following formulation:

$$\text{maximize } p^T u - \sum_{t \in D} \sum_{q,\, r \in R} x_{t,q,r} \cdot TC(q,\, r) \tag{16}$$

$$\begin{aligned} \text{s.t.} \quad & 0 \leqslant u \leqslant E[d], \\ & A_{(i,.)} \mathcal{I}_t(u) \leqslant \sum_{q \in R} x_{d,q,i}, \qquad \forall i \in R,\ \forall t \in D, \\ & \sum_{r \in R} x_{1,i,r} = cap_i, \end{aligned}$$

$$\sum_{r \in R} x_{t,i,r} = cap_i + \sum_{\tau=1}^{t} \left(\sum_{q_1 \in R} x_{\tau,q_1,i} - \sum_{q_2 \in R} x_{\tau,i,q_2} \right), \quad \forall t \in D \backslash \{1\} \tag{17}$$

$$x_{t,q,r} \in \mathbb{Z},\ x_{t,q,r} \geqslant 0, \qquad \forall q,\ r \in R,\ \forall t \in D, \quad u \in \mathbb{Z}^{|P|}.$$

NUMERICAL RESULTS

For our numerical test a small car rental network is considered, consisting of a suburb R_1, an airport R_2 and a downtown R_3 rental station. The demand is assumed to follow a Poisson distribution. All three stations types have very different weekly demand characteristics, see Figure 1 and Table 1. For the purpose of this model, we consider rentals with the length of 1 and 2 days.

Owing to the business customers there is a high demand at the airport on Monday, Tuesday and Wednesday. In contrast, the peak days at the non-airport stations are on Thursday, Friday and Saturday, mostly by leisure customers. At the airport, we also observe a weekend peak for LoR 2 rentals. Observing this demand behavior, we conclude that the transfer decisions can be very beneficial to the revenue and capacity utilization. We will use a simple price degression model. The prices are kept constant over all weekdays as stated in Table 2. Note that two LoR 1 rentals are more valuable than one LoR 2 rental.

We only consider one car type and the rental product is hence a combination of pickup day, rental station and LoR. The fleet size of 100 cars is assumed to be the optimal solution of the long-term fleet planning process, which is not considered here. The initial fleet distribution between stations is 15 cars at the suburb station (R_1), 55 cars at the airport (R_2) and 30 cars at the downtown station (R_3), relative to their weekly demand. The numerical experiments are started with an empty system, where all cars are idle at the beginning of the time horizon. The transfer costs of cars between the stations are given in Table 3.

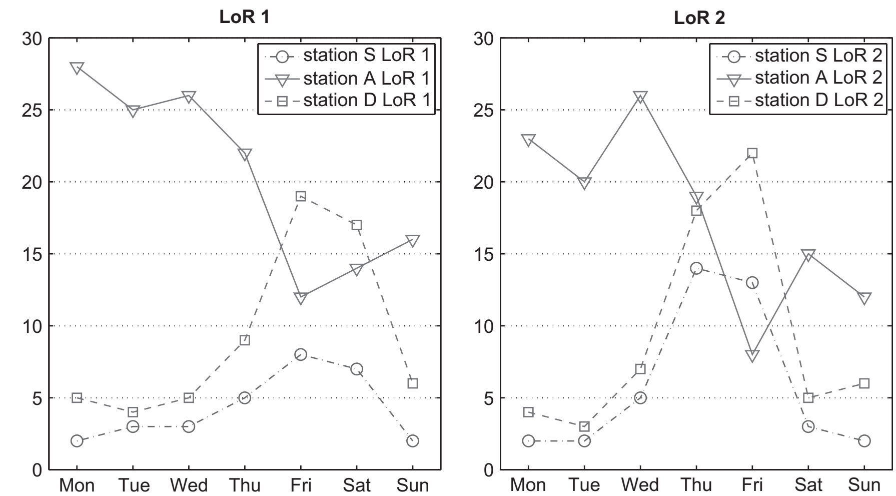

Figure 1: In-week demand behavior per rental station and LoR.

Table 1: Demand Poisson rates per rental station, LoR and weekday of pickup

	Monday	*Tuesday*	*Wednesday*	*Thursday*	*Friday*	*Saturday*	*Sunday*
R_1 LoR 1	2	3	3	5	8	7	2
R_1 LoR 2	2	2	5	14	13	3	2
R_2 LoR 1	28	25	26	22	12	14	16
R_2 LoR 2	23	20	26	19	8	15	12
R_3 LoR 1	5	4	5	9	19	17	6
R_3 LoR 2	4	3	7	18	22	5	6

Table 2: Rental prices per station and LoR

R_1 *LoR 1*	R_1 *LoR 2*	R_2 *LoR 1*	R_2 *LoR 2*	R_3 *LoR 1*	R_3 *LoR 2*
74	133	61	108	96	170

Table 3: Transfer costs between rental stations

Transfer between stations	*Transfer costs TC*
$R_1 \leftrightarrow R_2$	50.00
$R_1 \leftrightarrow R_3$	45.00
$R_2 \leftrightarrow R_3$	70.00

The performance of the two previous described capacity control models: the SIP (14) and the DIP (16), are tested by means of simulation with 1000 independent demand realizations. They are evaluated based on the two control actions (booking limits and fleet distribution). The models are tested on time periods of 1 and 2 weeks, both starting on Monday. The optimization model is solved in advance and the optimal control actions are applied to the demand scenarios over the two different time periods, that is, we are not re-optimizing during the pickup period. For the SIP, we generated $|S|=300$ independent demand scenarios by Monte Carlo simulation. To reduce the program size, we apply the Backward Scenario Reduction Algorithm proposed by Heitsch and Römisch (2009) (Algorithm 2.2 with parameter $r=1$, $\varepsilon=0.3$ and $q=0.65$). The method reduces the sample size by deleting scenarios with a small L_r distance to another scenario and adding its probability to the remaining neighbor. By the reduction algorithm, we are able to reduce the number of scenarios to 187 (simulation run of pickup period of 1 week with transfers), 184 (simulation run of pickup period of 1 week without transfers) and 194 (simulation run of pickup period of 2 weeks with transfers). The computation was performed on a Windows PC with 2×2.00 GHz and 2 GB RAM and the optimization problems are solve by FICO Xpress 7.0 (optimizer version 20.00.05).

Considering a pickup period of 1 week, Table 4 shows the generated revenues (*Rev*). The *Total Net Rev* denotes the real net obtained revenue, that is total generated revenue subtracted transfer costs.

In net revenue obtained over the whole network, we observe a gain of 5.3 per cent of using the stochastic approach compared to the deterministic one. On station level, the SIP results in a slightly lower revenue at station R_2 but larger yields at the other two stations. Concentrating on the 2-week pickup period, Table 5, we observe similar results. Using the controls generated by the SIP, we have on average percentage gain of 5.4 per cent compared to the DIP.

Now, we investigate the impact of the variable capacity, by setting the transfer costs to 1000, so that no transfer can be profitable and fleet distribution between the stations stays constant. In this case, the *Total Rev* and the *Total Net Rev* are equal. The results are shown in Table 6.

The usage of the SIP results in a surprising gain of 6.2 per cent and in a significantly higher mean revenue at all three stations. Comparing the obtained mean revenues for 1-week pickup period, we find that the DIP improves with 2.7 per cent much more than the SIP with only 1.9 per cent by adjusting the fleet distribution in the network. Examining the statistics of generated revenues (Table 7), we conclude that the SIP statistically outperforms the DIP in all simulation settings.

Also the minimum and maximum generated revenues in our simulation sample are higher for the SIP. Table 8 compares the number of car transfers and resulting costs.

For the pickup period of 1 week: the DIP gives 30 transfer orders, which results in transfer costs of 1780. In contrary, the SIP only uses 14

Table 4: Generated mean revenues for 1 week

	Rev R_1	*Rev R_2*	*Rev R_3*	*Total Rev*	*% gain SIP*	*Total Net Rev*	*% gain SIP*
DIP	4455	18 653	13 939	37 046	—	35 266	—
SIP	5217	18 398	14 468	38 083	2.8	37 143	5.3

Table 5: Generated mean revenues for 2 weeks

	Rev R_1	*Rev R_2*	*Rev R_3*	*Total Rev*	*% gain SIP*	*Total Net Rev*	*% gain SIP*
DIP	9511	37 540	27 023	74 074	—	69 454	—
SIP	10 624	36 820	28 019	75 463	1.9	73 213	5.4

Table 6: Generated mean revenues for 1 week with no car transfers

	Rev R_1	*Rev R_2*	*Rev R_3*	*Total Rev*	*% gain SIP*	*% gain transfers*
DIP	4435	18 128	11 774	34 337	—	2.7
SIP	4863	19 005	12 582	36 450	6.2	1.9

Table 7: Statistics of generated net revenues

	Remark	*Min*	*Max*	*SD*	*99% CI on mean Revenue*
DIP	1 week wT	30 834	38 164	1129	[35 266 ± 92]
SIP	1 week wT	33 016	40 494	1230	[37 143 ± 100]
DIP	1 week NoT	28 438	36 764	954	[34 336 ± 78]
SIP	1 week NoT	30 627	40 606	1269	[36 449 ± 103]
DIP	2 weeks wT	64 796	73 576	1560	[69 454 ± 127]
SIP	2 weeks wT	68 129	77 863	1705	[73 212 ± 139]

Abbreviations: wT – with transfers; NoT – without transfers; CI – confidence interval; SD – standard deviation.

Table 8: Number of transfer decisions and corresponding transfer costs

	Remark	*No. of transfers*	*Transfer costs*
DIP	1 week	30	1780
SIP	1 week	14	940
DIP	2 weeks	78	4620
SIP	2 weeks	37	2250

car transfers with transfer costs of 940. This explains the rather small gain of using the SIP in *Total Rev*, but the significant gain of 5.3 per cent in the attained net revenue. From the stochastic model, we already obtain very sophisticated booking limits and it is therefore not forced to adjust to the demand pattern using transfers with the same effort as the DIP. A second reason, why the SIP works with less transfers, is its knowledge of the demand uncertainty, resulting in an aversion of too many expensive transfers. Considering a pickup period of 2 weeks the optimization model has to adjust the fleet distribution not only to the different demand behavior from in-week to weekend, but also readjust from weekend to in-week and a second time in-week to weekend. This explains why the transfers and transfer costs more than double if we consider 2 weeks.

Another important Key Performance Indicator (KPI) is the capacity utilization (Cap

Util), that is the ratio between sold and available capacity. Table 9 presents the mean utilization per station and across the network.

We find that the utilization of the whole network is strictly larger for the SIP. The improvement of the SIP over the DIP is largest in the case of no transfers (4 per cent) and reduces to 1 or 2 per cent in the case of transfers.

Table 10 gives sizes and computation times of the optimization problems, with a pickup period of 1 or 2 weeks. The problem size and therefore the computation times are extremely high for the SIP, which is mainly a result of the amount of scenarios considered in the model. As a test on a smaller scenario sample in the SIP for a pickup period of 1 week, we generated only 30 initial scenarios, which were further reduced to 20. The solution was computed in only 344 ms, but the total generated mean net revenue was reduced to 36 920, a loss of 0.6 per cent compared to the results of the SIP with the larger scenario sample. This shows that testing on the scenario sample size is very important to computational and revenue performance of the stochastic model.

To reduce the impact of the initial fleet distribution and the time horizon length in the comparison, both models are tested on a pickup horizon of 12 weeks. The generated revenues are only compared on the aggregated weeks 3–10, the mean revenue results are shown in Table 11. We find the SIP outperforming the DIP by 5.5 per cent, compared with 5.4 per cent on the 2-week time horizon.

Since the results of the first 2 and last 2 weeks are discarded, we can clearly conclude

Table 9: Generated percental mean capacity utilizations

	Remark	*Cap Util R_1 (%)*	*Cap Util R_2 (%)*	*Cap Util R_3 (%)*	*Total Cap Util (%)*
DIP	1 week wT	60	88	52	79
SIP	1 week wT	60	89	57	81
DIP	1 week NoT	55	75	57	74
SIP	1 week NoT	61	79	60	78
DIP	2 weeks wT	59	88	54	79
SIP	2 weeks wT	63	87	58	80

Abbreviations: wT – with transfers; NoT – without transfers.

Table 10: Computation times and problem sizes

	Period	*Cont. var.*	*Int. var.*	*Bin. var.*	*Constraints*	*Comp. time (ms)*
DIP	1 week	—	105	—	147	125
SIP	1 week	15 708	7959	7854	39 417	3907
DIP	2 weeks	—	210	—	294	187
SIP	2 weeks	32 592	16 506	16 296	81 775	11 750

Table 11: Mean revenues of a 12-week optimization period, where the first two and last two weeks are discarded (results of weeks 3–10)

	Remark	*Total Rev*	*Transfer costs*	*Net Rev*	*% gain SIP*
DIP	12-week run (evaluated weeks 3–10)	297 011	22 720	274 291	—
SIP	12-week run (evaluated weeks 3–10)	299 500	10 110	289 390	5.5

that the 5.5 per cent gain of the SIP over the DIP is owing to its advanced use of transfers and improved booking limits rather than adjustments to the initial fleet distribution. In practice, such optimization models are implemented on a rolling horizon and usually solved on a daily up to weekly basis. Hence, will the considered time horizon usually not exceed 2 weeks, similar to our main test setting.

CONCLUSION

In this article, we study the RM problem for a car rental network, in particular its special characteristic, the flexibility in the fleet distribution. We give the deterministic and stochastic problem formulation and present numerical results on a small network case. We find that the stochastic version outperforms the deterministic at the costs of computational performance. For both optimization models, we observe a significant gain for incorporating the flexible capacity into the problem compared to a fixed fleet distribution. Both models are essentially feasible for practitioners. However, the successful implementation of the SIP on large-scale problems depends on the available computational resources and the specific dimensions of the optimization problem; such as number of rental stations, maximum LoR and time horizon. Therefore, the financial benefit of the SIP has to be compared with the computation costs of the particular application case. Since such models are usually solved on daily or weekly basis, computation times of several minutes and hours are feasible. An other advantage of the stochastic program is that its dimension and thus the computation time can be limited to the amount of available resources by considering a smaller number of demand scenarios, often with only a small loss of revenue.

In further research, the re-optimization of the control decisions on a rolling horizon basis has to be studied in a dynamic context and also compared with multi-stage stochastic programming. The model can be extended for multiple car types, especially to incorporate multiple demand dependent car types with upgrade possibilities. The possibility of car transfers could also be extended, such that the company can choose between a bundle transfers by truck on a longer time period in advance and a more expensive individual car transfer on a short-term basis. A linear extension to multiple transfer batch sizes can be found in Schmidt (2009).

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Research Article

A model of competitive airline revenue management interactions

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Olivier d'Huart and Peter P. Belobaba

Massachusetts Institute of Technology, Cambridge, MA, USA

Olivier d'Huart received a 'Diplôme d'Ingénieur des Arts et Manufactures' degree from Ecole Centrale Paris in 2009 and graduated from the Massachusetts Institute of Technology (MIT) with a Master of Science in Transportation in 2010. This article presents part of the results of his Master's thesis, entitled 'A Competitive Approach to Airline Revenue Management'.

Peter P. Belobaba is Principal Research Scientist at MIT, where he teaches graduate courses on The Airline Industry and Airline Management. He is Program Manager of MIT's Global Airline Industry Program and Director of the MIT PODS Revenue Management Research Consortium. Dr Belobaba holds a Master of Science degree and a PhD in Flight Transportation Systems from MIT. He has worked as a consultant on revenue management systems at over 40 airlines and other companies worldwide.

Correspondence: Peter P. Belobaba, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Room 33-318, Cambridge, MA 02139, USA

ABSTRACT In this article we develop a model of the interactions between the revenue management (RM) practices of competing airlines. The theoretical model is supported by PODS simulation results that highlight the important role of passenger spill between airlines on RM seat allocations in competitive markets. We show that typical RM system forecasters that unconstrain historical bookings without accounting for competitive RM effects result in a double-counting of demand. Under current practice, the RM systems of airlines in oligopoly markets thus tend to generate higher forecasts, higher protection levels and, consequently, lower discount fare booking limits than equivalent monopolies.

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Keywords: airline revenue management; competition; monopoly; oligopoly; PODS

INTRODUCTION

Papers in the 'Future of Revenue Management' section of this Journal, such as Cary (2004) and Ratliff and Vinod (2005) have called for a 'competitive-aware' approach to revenue management (RM). While in the real world the bookings and total revenues captured by airlines are determined by the simultaneous RM allocation decisions of each competitor, traditional RM systems assume such competitive effects to be exogenous, and extrapolate the airline's own historical observed booking data to forecast future flight demand. Meanwhile, airlines have struggled to find an effective way to adjust the seat allocation decisions of their RM system to the availability actions of their competitors (d'Huart and Belobaba (2009) or Lua (2007)).

To tackle the issue of reciprocal interactions between the RM decisions of competing airlines, it is necessary to understand how competitive environments affect current airline

RM practices. A first step is to compare competitive RM scenarios with their equivalent monopoly RM scenarios. In this article we first present a short review of the literature on RM competitive interactions. We then develop a competitive model for airline RM and provide some theoretical results on the difference in terms of forecasted demands, booking limits, actual bookings and total revenues, both by airline and at the total market level, between an airline oligopoly and an equivalent monopoly. Finally, we present the results of simulations performed with the Passenger Origin Destination Simulator (PODS), which validate our model.

LITERATURE REVIEW

The first known study of the impact of RM under competitive market conditions was performed by Wilson (1995). A summary of his work was published as Belobaba and Wilson (1997). Wilson shows through PODS simulations that the benefits of an RM system to an airline are affected by the RM capabilities of its competitors. One airline improving its RM system leads to an increase of its revenues at the expense of its competitors. When both airlines improve their RM system, both benefit. More surprising are the common secondary findings of Ferea (1996) and Darot (2001) that two cooperating airlines can make more total revenues than an equivalent monopoly.

As for theoretical models, we only review those where prices for fare classes are a fixed exogenous variable, which reflects current airline RM practice. Parlar (1988) followed by Karjalainen (1992), Lippman and McCardle (1997) as well as Mahajan and van Ryzin (2001) develop a competitive version of the classic Newsboy Problem, in which a firm's strategy is to choose an inventory level for a single perishable good before a one period stochastic demand arrives.

Parlar proves the existence and uniqueness of a Nash equilibrium in his two-player game and gives lower and upper bounds for this equilibrium. Parlar also argues that perfect cooperation increases the well-being of both players as compared to competition. Lippman and McCardle as well as Mahajan and van Ryzin find some similar results, but restrict themselves to the case where the unit salvage value of an unsold product and the unit opportunity cost of a shortage in inventory are equal to 0, which is not the case in the airline fare class mix control problem. Karjalainen extends the case of Parlar to $n \geqslant 2$ players.

Netessine and Shumsky (2005) draw inspiration from Parlar to develop a pertinent theoretical study of competitive RM. They consider a duopoly version of Littlewood's (1972) fare class mix rule with two independent classes by airline. Each airline's strategy consists of its booking limit for the low fare class. Netessine and Shumsky show that a pure strategy Nash equilibrium exists, is unique and that best-response functions are decreasing. If one player increases his booking limit, then it is optimal for the other player to decrease his booking limit. (Although in their paper Netessine and Shumsky assert that booking limits under this competitive game are lower than under the cooperative game, we have discussed with the authors that their proof is erroneous as published.) Yet, through extensive numerical simulations, they found that the same conclusions can be drawn in many cases even if the assumption of booking limits being reached does not hold. Talluri and van Ryzin (2004) propose a graphical interpretation of this game.

Li *et al* (2008) have an approach similar to Netessine and Shumsky. They use a model with identical fares for both airlines, but different costs associated for each fare class and for each airline. They show the existence of a unique pure-strategy Nash equilibrium. They also show that if the two airlines are symmetric in prices, then choosing whether to set collusion optimal booking limits or competition optimal booking limits leads to a Prisoners Dilemma. In a shorter but similar study, Li *et al* (2007) had shown under another set of conditions that a symmetrical equilibrium exists, and that this competitive equilibrium has lower booking limits than a cooperative situation. It is interesting to note that Mahajan and van Ryzin (2001) also found that under competition, total market protection for higher classes would be higher than with cooperation, even though their restriction of the Newsboy Problem does not apply directly to airline RM. Gao *et al* (2010) also use the overflow model of Netessine and Shumsky, but do not consider a stochastic process for demand generation. They develop a worst-case analysis over all the possible demand scenarios within demand bounds. They also show the existence of a unique pure-strategy Nash equilibrium to their game, and prove that two equivalent airlines in capacity, fare structure and market share allocate less seats to lower fare classes than a monopoly.

All of the above models assume that demands for fare classes are independent. This can be appropriate in markets with fare structures having clear different restrictions for each fare class, also called fully restricted fare structures. Isler and Imhof (2008) introduce a game theoretic model for unrestricted (also called fenceless) fare structure environments, where restrictions are the same from one class to another, so that independence of demands no longer holds. The RM method they consider consists of the dynamic programming formulation of Gallego and van Ryzin (1994). Under these conditions, Isler and Imhof prove that at the limit of continuous fares there is a unique pure strategy, sub-game perfect equilibrium. The total market revenue associated with this equilibrium is in their case higher than the usual competition-blind optimization, but not as high as the perfect cooperation case.

To summarize, these papers have come to the same conclusions that:

- There exists a Nash equilibrium if both airlines compete rationally and take into consideration competitive effects.
- Airlines competing can benefit from taking into consideration competitive effects. They can benefit even more if they cooperate for their allocation of seat inventory to different fare classes.
- Best-response functions in terms of booking limits for equivalent competing fare classes at different airlines are decreasing. If one player increases his booking limit, then it is optimal for the other player to decrease his booking limit, and conversely.
- Total market booking limits are smaller under competition than under collusion.

Yet these theoretical models assume that RM games are perfect information games. In reality, airlines do not have perfect information as to the availabilities and/or protection levels of their competitors, and they use imperfect forecasts.

A COMPETITIVE MODEL FOR RM

Our competitive model of RM extends the model of Netessine and Shumsky (2005) to more than two fare classes and to the situation where demands between classes are not specifically independent. We also assume that demand is stochastic.

The demand that airlines observe is constrained and consists only of accepted bookings. We first define *non-constrained demand* for a fare class at an airline as the sum of the passengers who book the fare class at the airline plus the passengers who would have booked this fare class if it were available at the airline, but who cannot because the fare class is not available. Airline RM system forecasters typically estimate non-constrained demand by detruncating the observed constrained demand (accepted bookings). This estimate of non-constrained demand is referred to as *unconstrained demand* for a fare class, and is used by the RM optimizer to set protection levels.

In a competitive market, we can view non-constrained demand for an airline as split into three other components (different from the categorization of accepted and rejected bookings), as illustrated in Figure 1. The first component, *first-choice non-constrained demand*, is

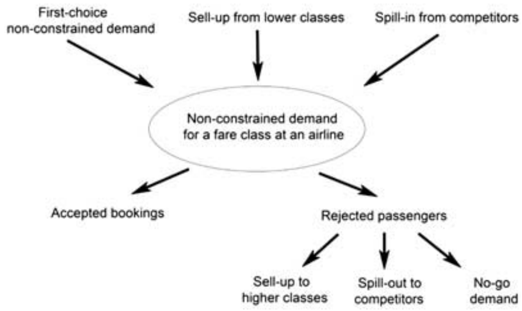

Figure 1: Competitive model: Decomposition of non-constrained demand.

the initial share of total market non-constrained demand that would book the fare class on the airline as a first-choice preference. The sum of the first-choice non-constrained demands for each airline is equal to the total market non-constrained demand. The second component, *spill-in*, corresponds to passengers who would prefer to book an equivalent fare class on a competitor but who were rejected because this fare product was no longer available at the competitor. We use the term *spill-in* for the passengers spilled by competitors and accepted by a specific airline, whereas *spill-out* designates passengers who are rejected by a specific airline and are added to the non-constrained demands of its competitors. The third component, *sell-up*, is the result of the decision by a passenger to book a higher fare class than his first-choice fare class but at the same airline, because his first-choice fare class is not available. Sell-up is a notion particularly relevant for fenceless fare structure environments.

A last conceivable category of passengers consists of *recapture*: passengers whose first choice is not available and who choose to fly on another path offered by the same airline rather than selling up on the same path with any other airline. In order to focus on competitive effects, our model assumes a single origin-and-destination market and a single daily flight by each competitor. As will be discussed later, we believe that taking recapture into account should not change our overall conclusions.

Among the observed bookings for the fare class of an airline, some consist of first-choice bookings, some are bookings by passengers who would have preferred to buy the competitor's fare class but who spilled-in, and some are people who would have preferred a lower fare class at the same airline but who had to sell-up. Among the passengers that an airline rejects for a specific class, some will consider buying a higher fare class (sell-up) at this same airline. Some considered this airline as a first-choice but will spill-out to equivalent fare classes at the competitors. Others are passengers who were already rejected by one competitor, and therefore they will either spill-out to the remaining competitors or not book on any airline. We call the latter *no-go demand*.

Figure 2 is a graphical representation of this model for the duopoly scenario of determination of a nested protection level. We

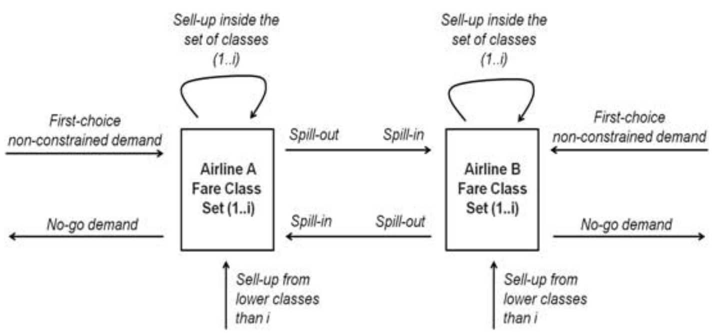

Figure 2: Competitive model: duopoly situation – Nested protection levels for higher fare classes.

assume the two competing airlines offer equivalent competing fare classes.

MONOPOLY VERSUS OLIGOPOLY

In order to isolate the effect of competition on the current practice of automated seat inventory control, we compare a monopoly and an oligopoly in 'equivalent RM situations'. That is, we assume that the oligopoly offers the same total market capacity as the monopoly, that the airlines use the same RM method, offer the same fare structure, and that competition does not boost total market non-constrained demand. These conditions are not met in most actual airline competitive markets but are assumed here to uncover the mechanisms of competitive interaction between airline RM systems, holding all else equal.

The comparison of equivalent monopoly and oligopoly RM situations using the demand framework introduced above highlights the importance of spill between airlines. Under competition at the total market level, passengers who are at some point spilled to a competitor are double-counted as part of the non-constrained demand of more than one airline. Each airline tries to estimate its own unconstrained demand for a fare class to account for unobservable spill. Spilled passengers increment the non-constrained demand of the airline of their first-choice preference, as well as the non-constrained demand of the competitor(s) to which they spill-in. The similar phenomenon of double-counting due to the recapture of passengers within a single airline and among different paths serving the same market has been documented by Ja *et al* (2001) as well as Andersson (1998). The consequent model proposed by Ratliff *et al* (2008) includes some consideration of double-counting due to spill-out to competitors, but does not concentrate on this phenomenon.

Such double-counting of passengers at the total market level does not occur if there is only a single carrier serving the market. Therefore the sum of the non-constrained demands for each airline of an oligopoly will be larger than the non-constrained demand for an equivalent monopoly. Even if the detruncation models of RM forecasters are reasonably accurate, the sum of the unconstrained demands forecasted by airlines in an oligopoly will be larger than the total market non-constrained demand, and larger than the unconstrained demand estimated by the airline in a monopoly market.

Unconstrained demands are statistical distributions used by airlines to set their protection levels. Under current RM practice, protection levels set by individual airlines increase linearly (directly) with the expected value of their forecasted unconstrained demand for the highest fare class(es). As long as these protection levels do not increase super-additively with the demand forecast and as long as the distributions of the unconstrained demands are not too variable, the sum of the protection levels set by each airline for a class in an oligopoly will be higher than the protection level set for the same class by an equivalent monopoly. We show this result for the widely used EMSRb algorithm in the Appendix.

The phenomenon of sell-up should only strengthen this result. Each airline detruncates its observed lower class bookings, given that the class was not available, while at the same time including the observed sell-up bookings in the unconstrained demand of the higher class as well. If the total market capacity and the non-constrained demand of the oligopoly are the same as the equivalent monopoly, sell-up is larger in competition because some passengers will have a preference for a specific airline. Some passengers will prefer to sell-up to higher classes at their first-choice airline rather than spill-out to a lower class at a competitor. As a direct consequence, the double-counting at the total market level of the non-constrained demands of the highest classes attributable to sell-up is thus greater in a competitive setting than in an equivalent monopoly situation. When comparing an oligopoly with an equivalent monopoly there is therefore greater double-counting of demand due to sell-up plus double-counting of competitive spill of demand.

Similarly, airline preference will also cause more passengers to be recaptured on different flight paths of their preferred airline rather than spill-out to competitors. This will make double-counting of passengers owing to recapture among different flight paths more important at the total market level in a competitive setting than in an equivalent monopoly situation.

Figures 3 and 4 represent an example of a monopoly RM situation and its equivalent duopoly RM situation with our model, where airlines set a nested protection level for a set of high fare classes. μ designates the average value of a distribution. Total market non-constrained (first-choice) demand for these higher classes has an expected value $\mu = 80$. In Figure 3, we assume that the monopolist applies an average protection level of 80, based on a forecast of mean unconstrained demand equal to 99. With demand stochasticity, and given that the booking limit of the lower classes is assumed to always be reached, it observes an average of 78 accepted bookings. But these accepted bookings come not only from the non-constrained (first-choice) demand with mean 80, they also include demand for lower classes that has been forced to sell up. The average total number of passengers considering this set of fare classes is 90, and the no-go demand for the monopoly is 12 passengers.

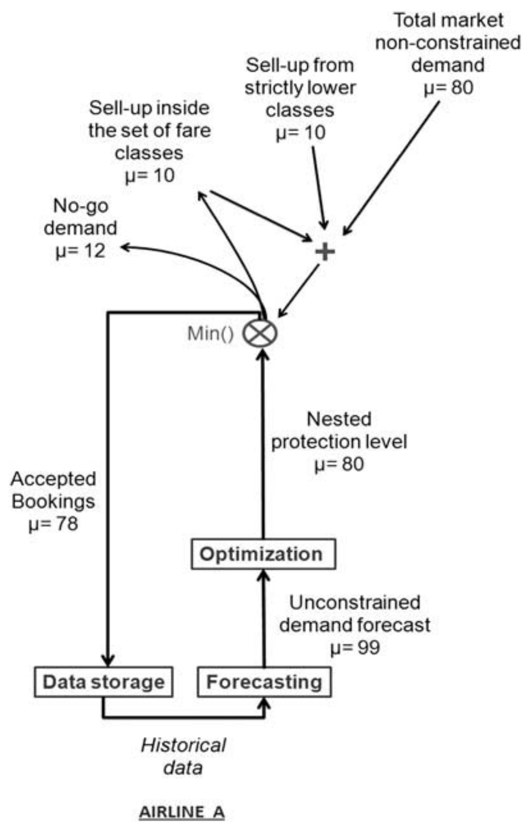

Figure 3: Determination of a nested protection level by a monopoly.

In the equivalent duopoly situation where passengers spill between airlines, we assume each airline has a first-choice non-constrained demand of $\mu = 40$ corresponding to half of the total market non-constrained demand. With an average protection level of 45 based on an average unconstrained forecast of 57, each airline accepts on average 44 bookings. Each airline receives a total of 57 requests for the higher class, consisting of 40 first choice, 6 sell-up from strictly lower classes, 6 sell-up within the fare classes for which the protection level is set and 5 passengers spilled in from the competitor. Of the 51 total passengers considering a specific set of fare classes at an airline, the airline accepts 44, spills out 5 to the competitor and loses 2 passengers to the no-go category.

On the basis of observed bookings with mean 44, each airline uses detruncation methods to increase its estimate of unconstrained demand to 57, which results in the nested protection level of 45. Thus, total market protection for the nested high class is on average 90 seats (as compared to 80 for the monopoly), total market unconstrained forecasts are on average 114 (as compared to 99 for the monopoly), total market accepted bookings in the high class are on average 88 (as compared to 78 for the monopoly), and total no-go demand is on average 4 (as compared to 12 for the monopoly).

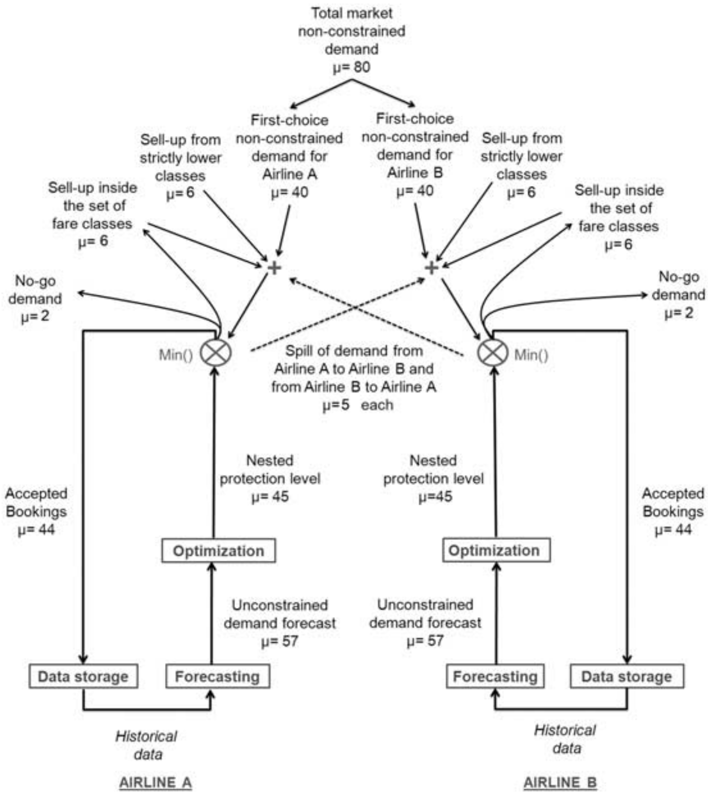

Figure 4: Determination of a nested protection level by a duopoly.

Results of the existing literature corroborate this general intuitive idea. We provide in the appendix proofs that an oligopoly will protect more seats for high classes than an equivalent monopoly for RM applied to nested fare classes. The proofs assume that all airlines have the same fare structure, use EMSRb (Belobaba, 1992), that non-constrained demands for fare classes are independent, that the initial share of the total market non-constrained demand by airline is the same for all fare classes and that lower fare class booking limits are reached (Littlewood's rule). The proofs do not account for sell-up, but as in the above illustrative examples, the inclusion of sell-up in the passenger choice characterization only serves to reinforce the overall results.

SIMULATIONS

To confirm both the intuitive idea presented above and the theoretical proofs in the Appendix, we used PODS. PODS is currently used at MIT within an RM research consortium of nine airlines. It replicates on the one hand the functioning of airline RM systems in competitive networks and on the other hand the separate process of passenger choice among flights and fare classes made available by the competing RM systems. Its representation of passenger and airline behavior is closer to the real world of airline RM than the restrictive hypotheses of the presented theoretical results.

The simulated airline RM systems comprise a historical database, a forecaster and an optimizer. The passenger choice module generates passengers with various characteristics: an origin and a destination, a passenger type (business or leisure), a maximum willingness to pay, an airline preference, a path preference, a time-of-day preference and restriction disutilities. A passenger books the available travel alternative whose actual fare is less than his willingness-to-pay, and which has the lowest generalized cost to him, where the generalized cost is the sum of the actual fare and the disutility costs associated with fare restrictions, path quality and unfavorite airline, among others. A detailed description of the PODS simulator, the parameters used and their calibration can be found in d'Huart (2010), Hopperstad Consulting (2005) or Lua (2007).

We simulated a single market competitive environment to exclude network effects. The monopoly scenario consisted of one airline operating three flights a day, at three different times, in one direction and with three aircraft with 240 seat capacity each. The equivalent oligopoly scenarios simulated are with two, three or four airlines competing. As in the monopoly situation, each airline operates three flights a day, at the same times, in the same direction, and the capacity of the aircraft in each competitive scenario is such that the total capacity offered in the market remains 240 seats per departure time. In the competitive case, airlines all keep the same fare structure, forecasting and optimization methodologies as the monopoly. Figure 5 summarizes the scenarios. We calibrated the demand levels so that load factors are in the typical current range of 80–85 per cent.

PODS allows us to isolate the actual impacts of spill-in and sell-up of demand. It can be run in a 'First Choice Only Choice' (FCOC) mode, in which if a passenger does not get his first choice for a fare class and flight, he will not spill-out to another airline nor sell-up to another fare class. In this mode, the non-constrained demand for a competing airline is only its first-choice non-constrained demand. This mode helps us to estimate the impact of spill-in and sell-up by comparing FCOC results with results obtained in 'normal mode'.

We show the results for two fare environments and typical RM systems representative of current real-world practice. In Scenario A, the airline(s) use an unrestricted fare structure, with no restrictions or advance purchase restrictions rules as shown in Table 1. Both airlines use EMSRb optimization with Q-forecasting (Belobaba and Hopperstad, 2004) for unrestricted fare structures, and booking curve detruncation (Hopperstad Consulting, 2005). In Scenario B, the airlines use a fully restricted fare structure, with each fare class having its own set of restrictions and advance purchase

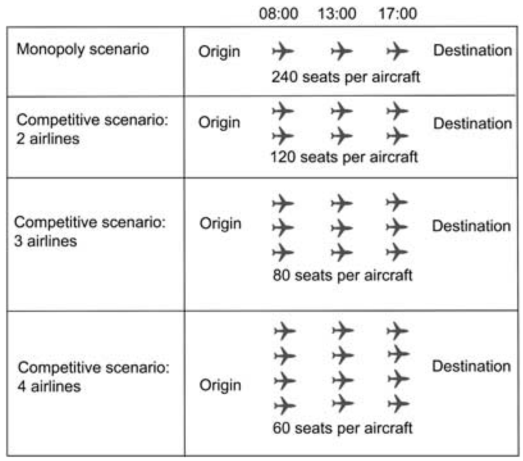

Figure 5: Simulated single market monopoly and competitive scenarios.

Table 1: Scenario A: unrestricted fare structure

Class	*Fare*	*Advance purchase (days)*	*Saturday night stay*	*Change fee*	*Non-refundable*
1	500	0	No	No	Yes
2	400	0	No	No	Yes
3	315	0	No	No	Yes
4	175	0	No	No	Yes
5	145	0	No	No	Yes
6	125	0	No	No	Yes

Table 2: Scenario B: fully restricted fare structure

Class	*Fare*	*Advance purchase (days)*	*Saturday night stay*	*Change fee*	*Non-refundable*
1	500	0	No	No	No
2	400	3	No	No	Yes
3	315	7	No	Yes	Yes
4	175	10	Yes	Yes	Yes
5	145	14	Yes	Yes	Yes
6	125	21	Yes	Yes	Yes

rules, as shown in Table 2. Both airlines use EMSRb optimization and pick-up forecasting with booking curve unconstraining.

Simulation results: Scenario A with unrestricted fare structure

Figure 6 displays the average sum of the forecasts of the airlines for the 08:00 flight at 24 days before departure, when first-choice non-constrained demands are equally distributed between airlines. For all the fare classes, the sum of the mean values of airline unconstrained forecasts in competition is, as expected, larger than the mean value of the unconstrained forecast made by the monopoly.

As shown in Figure 7, such forecasts cause the associated total market nested booking limits on lower fare classes to be smaller under competition than under monopoly. The lower the price of the fare class, the larger the difference in booking limits between the monopoly case and the oligopoly case. (Note that in Figure 7 and several subsequent figures, we have changed the vertical axis in order to provide a clearer indication of the differences.)

Figure 8 represents the consequent average total market daily bookings by fare class. The oligopoly has fewer bookings in the cheapest fare class 6 due to lower booking limits, but higher bookings in all the upper classes. As a result, the oligopoly generates higher total revenues through lower load factors and higher yields than the monopoly, as shown in Figures 9 and 10. The higher total revenue of the oligopoly is a result of the higher protection levels causing more passenger sell-up in this unrestricted fare environment. In this case, the higher protection levels caused by competitive interactions in the oligopoly actually help to increase revenues for both competitors.

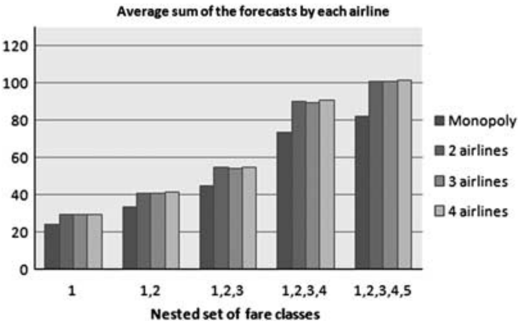

Figure 6: Average sum of airline forecasts, 08:00 flight, 24 days prior departure.

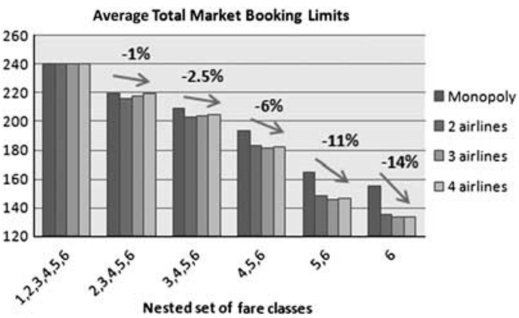

Figure 7: Average sum of airline nested booking limits, 08:00 flight, 24 days prior departure.

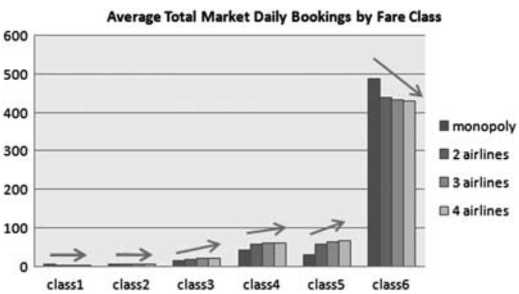

Figure 8: Average total bookings by fare class.

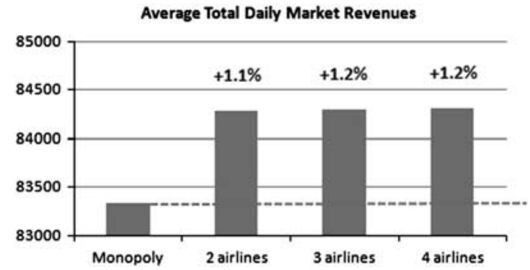

Figure 9: : Average total daily market revenues.

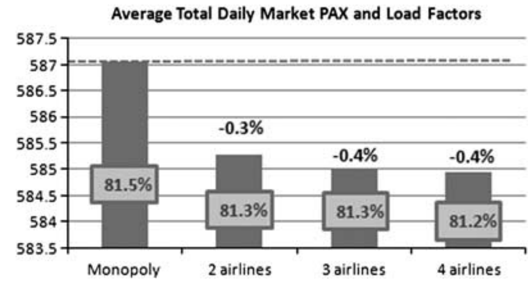

Figure 10: : Average market load factor.

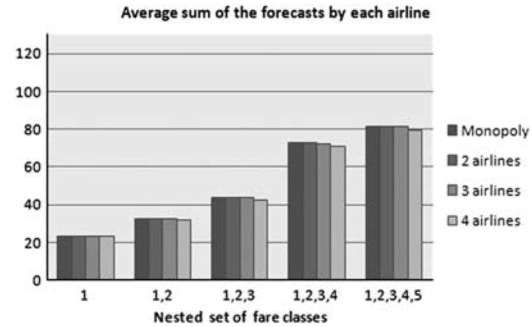

Figure 11: FCOC – average sum of airline forecasts, 08:00 flight, 24 days prior departure.

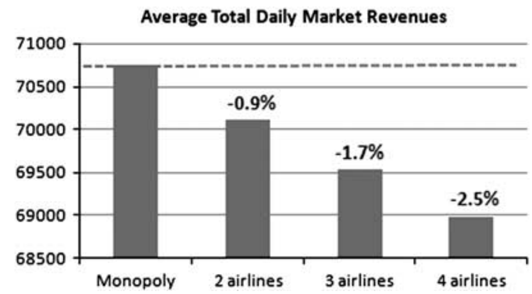

Figure 12: FCOC – average total daily market revenues.

If we run the same scenario in the FCOC mode, we no longer see the same results. With FCOC, in an oligopoly, total market unconstrained forecasts are less than or similar to the monopoly level for all fare classes, as shown in Figure 11. As a result, total market booking limits on lower fare classes are higher or similar to the monopoly level. Both total market revenues (Figure 12) and load factors decrease as compared to the monopoly level. These FCOC results confirm that spill-in and sell-up of demand lead to the smaller booking limits observed in the competitive case as compared to the monopoly case. In the competitive case, estimates of spill-in and sell-up can account for 25 per cent of unconstrained forecasts.

We verified that the same results hold irrespective of the initial allocation of total market first-choice non-constrained demand among the competing airlines (the above results were based on an equal distribution of first-choice non-constrained demand). Results suggest that the distribution among airlines of first-choice non-constrained demand naturally has an impact on the individual performance of airlines. Yet at the scale of the total market, the differences between a duopoly and a monopoly described above hold whatever the initial distribution of non-constrained demand among airlines. A more extensive description of the results can be found in d'Huart (2010).

Simulation results: Scenario B with restricted fare structure

Figure 13 displays the average sum of the forecasts of the airlines for the 08:00 flight at 24 days before departure, when first-choice non-constrained demands are equally distributed between airlines. We find in Scenario B that in the competitive scenario the sum of the average airline unconstrained forecasts is not always higher than the average forecast made by the equivalent monopoly. It is true for the lowest classes 4 and 5, but not for the highest classes. Yet, under competition the sum of the airline unconstrained forecasts for all

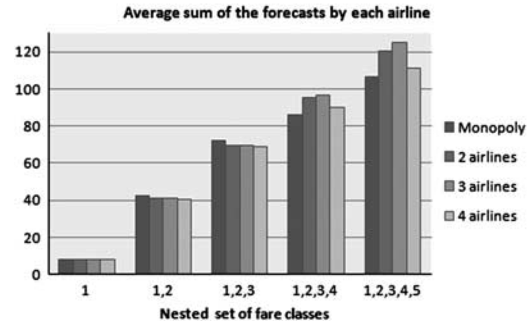

Figure 13: Average sum of airline forecasts, 08:00 flight, 24 days prior departure.

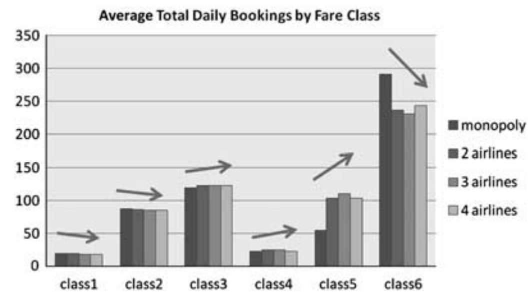

Figure 14: Average total daily bookings by fare class.

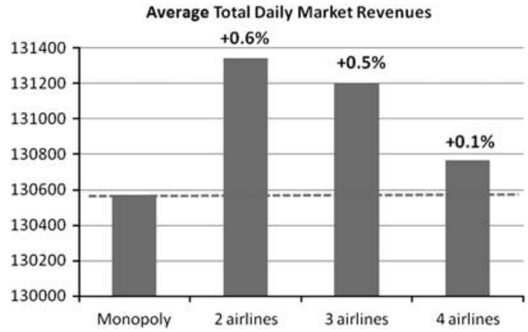

Figure 15: Average total daily market revenues.

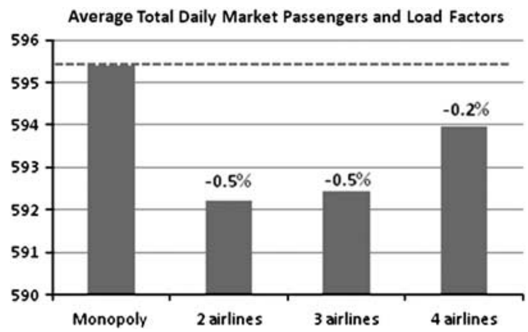

Figure 16: Average total daily market load factors.

classes together is higher than the unconstrained forecast for all classes made by the monopoly. The difference in forecasts by class between the monopoly case and the competition case is much larger for the lowest classes than for the higher classes.

As a consequence, in competition total market nested booking limits are smaller than under the monopoly scenario only for the lowest fare classes 6 and $(5, 60)$. Total market bookings in competition are slightly lower for the most expensive fare classes, higher for the 'middle' fare classes, but lower for the cheapest fare classes (Figure 14). Yet, the oligopoly again generates higher total market revenues through higher yields and lower load factors, as shown in Figures 15 and 16. With a more restricted fare structure than in Scenario A, the increase in total market revenues is less significant, but it still reflects the beneficial impacts on sell-up and revenues for both competitors of the higher oligopoly protection levels.

As for Scenario A, we ran the equivalent FCOC simulations. We found that in an oligopoly, without any spill-in or sell-up, the total market unconstrained forecasts are smaller as compared to the monopoly level, whereas total market booking limits are higher. For all classes overall total market bookings slightly decrease, and both total market revenues and load factors decrease as compared to the monopoly level.

This once more confirmed that spill-in and sell-up of demand are responsible for the smaller booking limits for the cheapest fare classes observed in the competitive case as compared to the monopoly case. In the competitive case, spill-in and sell-up can account for 40 per cent of the total market forecasts for the set of classes $(1, 2, 3, 4, 5)$, but this occurs mostly in classes 4 and 5. The slightly lower relative forecasts observed for the highest classes are explained by the greater product differentiation in this restricted fare structure. With the added restrictions on classes 4–6, bookings in classes 1–3 do not depend on the closure of the lower classes to be recorded and the closure rates of these classes are lower than in an unrestricted fare structure. Spill- and sell-up play a less important role with this product differentiation, making the impacts of aggressive detruncation on 'over-forecasting' not as apparent.

As in Scenario A, the same results were found whatever the initial allocation of total market first-choice non-constrained demand among the competing airlines. At the scale of the total market, the differences between a duopoly and a monopoly enumerated above hold whatever the initial distribution of non-constrained demand among airlines.

SUMMARY AND CONTRIBUTIONS

The objective of this article was to further the existing literature on the competitive effects of RM. We developed a competitive framework to explain the interactions between RM practices of airlines in competition. This framework extends the models of past literature and is valid for traditional restricted fare class structure environments as well as fenceless fare class structure environments. As a first step toward understanding interactions between inventory control decisions of competing airlines, we used this model to compare the RM situation of an oligopoly at the total market level as compared to an equivalent monopoly situation. In this analysis of 'equivalent' monopoly and oligopoly markets, we assumed no increase in total market capacity with increasing competition. In the real world, increasing competition typically means more capacity, which leads to greater availability of discount fare seats and lower overall yields.

In our 'equivalent' market analysis, we showed that under traditional RM practice, an oligopoly tends to set higher total market seat protection levels than an equivalent monopoly because of the detruncation models used by RM forecasters. By detruncating their historical observed demand, airlines want to account for passengers they have rejected by closing down fare classes. But these rejected passengers have potentially booked at competitors, so that at the total market level, double-counting of passengers occurs, and an oligopoly generates higher forecasts than an equivalent monopoly with the same fare structure, RM system, seat capacity and overall non-constrained demand. Results of past literature concur with this idea. The phenomena of passenger sell-up across classes and passenger recapture across flight paths should only strengthen this result. We proved this behavior for airlines using EMSRb, and presented some corroborating PODS simulations for both unrestricted (fenceless) and traditional restricted fare structures.

We highlighted the importance of passenger spill between airlines in a competitive RM setting, which in our simulations accounted for as much as 40 per cent of non-constrained demand for a fare class at an airline. Our model of RM interactions through spill of passengers provides a basis for further work on how to use 'competitive awareness' to improve the efficiency of current RM practice. In d'Huart (2010), we use spill considerations and a game theoretical approach to describe how an airline can adjust its own seat inventory decisions to account for the seat inventory allocations of its competitors. We also suggest that rather than directly manipulate protection levels as a competitive move, a wiser approach could be to adapt forecasters. Forecasts could be adjusted based on information about the seat availabilities of competitors, posing the question whether RM efficiency could improve if seat allocation decisions were to become perfect information available to all competitors.

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APPENDIX

Proposition A:

Suppose:

- A market where N airlines have an identical 2-fare-classes structure.
- Total market non-constrained demand for each fare class is a stochastic independent variable.
- Booking limits for the low fare class are reached.
- There is an initial share between airlines of the total market non-constrained demand for the high fare class based on passenger first-choice preference.
- Unconstrained forecasts accurately estimate non-constrained demands (non-constrained demand is equal to unconstrained demands).

Then:

- The total market protection level for the high fare class is higher under competition than under monopoly, regardless of the capacities.
- If the oligopoly does not offer a strictly higher total market capacity than the monopoly, total market booking limits are smaller in the oligopoly than in the monopoly.

Proof:
Let:

- d_1 be the stochastic total market non-constrained demand for the high fare class 1.
- p_i be the fare of fare class i.

- $\lambda^j \in [0;1]$ be the proportion of the total market non-constrained demand for the high fare class 1 that has a preference for airline j. By definition $\sum_{j=1.N} \lambda^j = 1$.
- $d_1^j = \lambda^j . d_1$ be the stochastic first-choice non-constrained demand for the high fare class 1 of airline j.

The monopoly non-constrained demand for the high fare class is d_1. The monopoly optimizes its revenues using Littlewood's two class rule (a detailed description of this rule can be found in Talluri and van Ryzin (2004, pp. 35–36) and with unconstrained forecasts accurately estimating demand d_1.
Let:

- $\varepsilon_1^j \geqslant 0$ be the stochastic spill-in of demand toward airline j, fare class 1.
- $D_1^j = d_1^j + \varepsilon_1^j$ be the stochastic total non-constrained demand for airline j, fare class 1.

Let :

- X: $d \to X(d)$ be the application associating a positive stochastic demand d for the high class with its Littlewood protection level. $X(d)$ is the solution of

$$\Pr(d \geqslant X(d)) = \frac{p_2}{p_1}. \tag{3.1}$$

X is such that:

- X does not depend on the airline.
- X is a positive homogenous application: $\forall a \in \Re^+$, $X(a.d) = a.X(d)$.

  This results directly from the fact that

$$\Pr(d \geqslant X(d)) = \Pr(a.d \geqslant a.X(d)) = \frac{p_2}{p_1}.$$

- $X(d + d^*) \geqslant X(d)$ for any set of stochastic positive demands d and d^*.

  This can be shown knowing that:
  1. by definition of X,

$$\Pr(d + d^* \geqslant X(d + d^*)) = \Pr(d \geqslant X(d)) = \frac{p_2}{p_1}$$

  2. for d, d^* positive stochastic demands, x a real constant,

$$\Pr(d + d^* \geqslant x) \geqslant \Pr(d \geqslant x)$$

  3. for a given distribution of the demand d, $x \to \Pr\ (d \geqslant x)$ is decreasing in the real variable x

  Therefore we obtain:

$$X(d_1) = \sum_j \lambda^j . X(d_1)$$

$$= \sum_j X(\lambda^j d_1)$$

$$= . \sum_j X(d_1^j) \tag{3.2}$$

$$X(d_1) \leqslant \sum_j X(d_1^j + \varepsilon_1^j) = \sum_j X(D_1^j)$$

$X(d_1)$ is the protection level set by the monopoly and $\sum_j X(D_1^j)$ is the sum of the protection levels set by the competing airlines. This inequality shows the first point of Proposition A. The second point of Proposition A comes from the definition of a booking limit as the flight capacity minus a protection level. □

With the same general reasoning and provided additional assumptions, Proposition B extends the result of Proposition A to the case of $n>1$ nested protection levels and EMSRb optimization.

Proposition B

Suppose:

- A market where N airlines have an identical n-class fare structure.
- Total market non-constrained demand for each fare class is a stochastic independent variable.
- Nested booking limits on all lower classes are reached (Littlewood's rule).
- First-choice non-constrained demands is a fixed proportion of total market non-constrained demand for all the classes of an airline.

- Each airline optimizes its revenues with an EMSRb rule where the fare levels considered in the EMSRb equation are not adjusted (a detailed description can be found in Talluri and van Ryzin (2004, pp. 47–50).
- Unconstrained forecasts accurately estimate non-constrained demands (non-constrained demand is equal to unconstrained demands).

Then:

- The total market nested protection level for classes is higher under competition than under monopoly, regardless of the capacities.
- If the oligopoly and the monopoly offer the same total market capacity, total market nested booking limits are smaller in the oligopoly than in the monopoly.

Proof:

The overall reasoning is the same as for Proposition A, with complications due to nesting.

Let:

- d_i be the stochastic total market non-constrained demand for fare class i. $d_{1,\ldots,i} = \sum_{k=1,\ldots,i} d_i$ be the total stochastic market non-constrained demand for the set of classes $(1, \ldots, i)$.
- $(d_i)_{i=1,\ldots,n}$ constitute a set of independent stochastic variables.
- $(d_{1,\ldots,i})_{i=1,\ldots,n}$ thus also constitute a set of independent stochastic variables.
- p_i be the fare of fare class i.
- $\lambda^j \in [0;1]$ be the proportion of the total market non-constrained demand that has a preference for airline j. By definition $\sum_{j=1,\ldots,n} \lambda^j = 1$.
- $d_i^j = \lambda^j.d_i$ be the stochastic first-choice non-constrained demand for class i, airline j.
- $d_{1,\ldots,i}^j = \lambda^j.d_{1,\ldots,i}$ be the stochastic first-choice non-constrained demand for the set of classes $(1, \ldots, i)$ of airline j.

Let:

- $\varepsilon_i^j \geqslant 0$ be the stochastic spill-in of demand towards airline j, fare class i.
- $D_i^j = d_i^j + \varepsilon_i^j$ be the stochastic total non-constrained demand for airline j, class i.
- $\varepsilon_{1,\ldots,i}^j = \sum_{k=1.i} \varepsilon_k^j$ be the stochastic total spill-in of demand toward airline j for the set of fare classes $(1, \ldots, i)$.
- $D_{1,\ldots,i}^j = \sum_{k=1,\ldots,i} D_k^j = d_{1,\ldots,i}^j + \varepsilon_{1,\ldots,i}^j$ be the total non-constrained demand for airline j for nested classes $(1, \ldots, i)$.

Let :

- $X_{1,\ldots,i} : (\partial_1, \ldots, \partial_i) \to X_{1,\ldots,i}(\partial_1, \ldots, \partial_i)$ be the application associating a set $(\partial_1, \ldots, \partial_i)$ of demands for the classes of a set $(1, \ldots, i)$ with the nested protection level given by the non-adjusted EMSRb equation:

$$\Pr\Big(\sum_{k=1,\ldots,i} \partial_k \geqslant X_{1,\ldots,i}(\partial_1, \ldots, \partial_i)\Big) = \frac{p_{i+1}}{\dfrac{\sum_{k=1,\ldots,i} p_k \overline{\partial_k}}{\sum_{k=1,\ldots,i} \overline{\partial_k}}} \tag{3.3}$$

- $X_{1,\ldots,i}$ does not depend on the airline because they have the same fare structure and the same initial share of the total market non-constrained demand by fare class.
- $X_{1,\ldots,i}$ is a positive homogenous application:

$$\forall a \in \Re^+, X_{1,\ldots,i}(a.\partial_1, \ldots, a.\partial_i) = a.X_{1,\ldots,i}(\partial_1, \ldots, \partial_i)$$

This results from the fact that:

$$\Pr\Big(\sum_{k=1,\ldots,i} \partial_k \geqslant X_{1,\ldots,i}\Big) = \Pr\Big(\sum_{k=1,\ldots,i} a.\partial_k \geqslant a.X_{1,\ldots,i}\Big) = \frac{p_{i+1}}{\dfrac{\sum_{k=1,\ldots,i} p_k \overline{\partial_k}}{\sum_{k=1,\ldots,i} \overline{\partial_k}}}$$

- $X_{1,\ldots,i}(\partial_1 + e_1, \ldots, \partial_k + e_k) \geqslant X_{1,\ldots,i}(\partial_1, \ldots, \partial_k)$ for sets of initial stochastic non-constrained demands $(\partial_1, \ldots, \partial_k)$ and of stochastic spill-in $(e_1, \ldots, e_k)$ with small enough variance.

Therefore we obtain:

$$
\begin{aligned}
\forall i\, X_{1,\ldots,i}(d_1,\ldots,d_i) &= \sum_j \lambda^j . X_{1,\ldots,i}((d_1,\ldots,d_i)) \\
&= \sum_j X_{1,\ldots,i}((\lambda^j d_1,\ldots,\lambda^j d_i)) \\
&= . \sum_j X_{1,\ldots,i}(d_1^j,\ldots,d_i^j) \qquad (3.4) \\
&\leqslant \sum_j X_{1,\ldots,i}(d_1^j+\varepsilon_1^j,\ldots,d_i^j+\varepsilon_i^j) \\
&= \sum_j X_{1,\ldots,i}(D_1^j,\ldots,D_i^j)
\end{aligned}
$$

$X_{1,\ldots,i}$ $(d_1,\ldots,d_i)$ is the protection level set by the monopoly for $(1,\ldots,i)$ and $\sum_j X_{1,\ldots,i}(D_1^j,\ldots,D_i^j)$ is the sum of the protection levels set by the competing airlines for $(1,\ldots,i)$. This inequality shows Proposition B. □

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