

UC Berkeley

Earlier Faculty Research

Title

Reducing Risks in Logistics Outsourcing

Permalink

<https://escholarship.org/uc/item/47v6f9fx>

Authors

Regan, A C
Wang, Chuanxu

Publication Date

2003-02-01

Reducing Risks in Logistics Outsourcing

Chuanxu Wang

Shanghai Maritime University

and

Institute of Transportation Studies

University of California, Irvine, California 92697

Amelia C. Regan

Institute of Transportation Studies

Department of Civil & Environmental Engineering

and

Graduate School of Management

University of California, Irvine, California 92697

aregan@uci.edu

ABSTRACT

Many firms have turned to logistics outsourcing as a way to restructure their distribution networks and gain competitive advantages. Logistics outsourcing in which a third party logistics (3PL) provider is contracted for all or part of an organization's logistics operations has seen consistently increasing use. Although there are clearly pros and cons of using logistics outsourcing, the full extent of both of these has not been adequately examined. This paper begins to examine some of these risks and discusses some risk reduction measures.

Key Words: Logistics Outsourcing, Third Party Logistics, Supply Chain Management

February, 2003

INTRODUCTION

Because of increasingly intensified competition in the emerging global economy, manufacturing and retail firms are increasingly turning to outsourcing their logistics functions. Motivated by the rapid increase in logistics outsourcing in certain regions of the world (Asia in particular), our research is focused on risks and risk prevention measures in the development of logistics outsourcing arrangements.

Outsourcing is a viable business strategy because turning non-core functions over to external suppliers enables companies to leverage their resources, spread risks, and concentrate on issues critical to survival and future growth (Sink, and Langley, 1997). Many firms have turned to logistics outsourcing as a way to restructure their distribution networks and gain competitive advantages. Logistics outsourcing, the use of a third party logistics (3PL) provider for all or part of an organization's logistics operations, has grown dramatically over the last several years. Logistics outsourcing has increasingly become an effective way to reduce costs and spread risks for traditional, vertically integrated firms. Overall, approximately 60 percent of Fortune 500 firms report having at least one contract with a third party logistics provider (Lambert, Emmelhainz and Gardner, 1999). And, the market for logistics outsourcing continues to grow (Economist, 2002).

A recent study by Persson and Virum(2001), discusses the potential economic advantages of logistics outsourcing. Some of these are: the elimination of infrastructure investments; access to world-class processes, products, services or technology; improved ability to react quickly to changes in business environments; risk sharing; better cash-flow; reducing operating costs; exchanging fixed costs with variable costs; access to resources not available in own organization. According to David G. Kulik, the president of Customized Transportation Incorporation (CTI), a leading third party logistics provider, an outsourcing agreement reached by CTI and General Motors (GM) contributed to the realization of GM's financial aims and reduction of inventory (Foster, 1999).

As recently as a decade ago, third party logistics was an emerging industry in many parts of the world. However, the rate at which use of these services grew, the rate of growth across functions and the reasons for this growth differed in different parts of the world. In Europe, firms tend to use third party logistics both for international transport and for the distribution of products in foreign markets. Nearly two-thirds of the European distribution centers used by American, Japanese, Korean and Taiwanese manufacturers are managed by third party logistics providers (Mckinnon, 1999). 3PLs helped firms deal with multinational transportation requirements and inconsistencies. In the US, there has been a recent trend for firms to focus on their core business competencies in order to create a sustainable competitive advantage. This has created a need for outsourcing support activities, therefore creating growth opportunities for 3PLs. Fila USA, for example, reports that its decision to outsource its athletic footwear and apparel distribution capabilities to Ryder Integrated Logistics "will enable the company to focus on its core competency of athletic footwear and apparel design, marketing and sales, while providing a significant reduction

in overhead costs." (Harps, L.H., 2001) In China, the top reason why firms outsource their logistics activities to 3PLs is a desire to reduce costs (Mercer Management Consulting, 2002). Today, third party logistics is a key component of logistics management strategy in many industries Gooley, (2002). Furthermore, the industry is experiencing rapid growth in Asia. Analysis of a 2002 survey organized by the Mercer Management Company and the China Logistics & Purchasing Council predicted that the Chinese 3PL market will likely increase at an average annual rate of 25% during the years 2000 to 2005 (Mercer Management Consulting, 2002). Recently, many urban governments in China have recognized the importance of the development of third party logistics. For example, the Beijing Municipal Government placed the establishment of a logistics base in its latest (tenth) five year development plan; the Shanghai Municipal Government recommended that Shanghai establish a first class logistics center; and, the Shenzhen Municipal Government plans to invest 150 billion RMB Yuan (\$18 Billion USD) to develop third party logistics into one of three mainstay industries in the 21st century. The latest available statistics show that the Chinese retail market reached 3420 billion RMB Yuan (\$413.5 Billion USD) in 2000, and that the ratio of logistics expenditures to this market was 1 to 5. Therefore, Chinese logistics expenditures in 2000 are estimated at about 684 billion RMB Yuan (\$82.7 Billion USD). It is estimated that expenditures related to third party logistics were about 136.8 billion RMB Yuan (16.54 Billion USD) (Xie, 2001).

China possesses the essential requirements for developing effective logistics and distribution systems. From a long-term point of view, if Chinese economic reforms continue, Chinese third party logistics will enter a new era. Demand for developing third party logistics from foreign owned enterprises is growing quickly; third party logistics demand from expanding domestic firms is strong; logistics and distribution centers serving medium and small retail enterprises are in demand; and, the logistics distribution industry within quickly developing retail chain enterprises are entering a more stable development period. In addition, though to a lesser extent, third party logistics companies are linking suppliers and consumers and serving non-counter (on-line, and mail-order) retailers. The rapid growth in Asia, and the continuing growth of 3PL on other continents makes it important to understand why some logistics outsourcing relationships work well and why others fail.

As evidenced by recent failures, not all logistics outsourcing activities are successful (Lambert et al, 1999). There are many risks that limit logistics outsourcing. The objectives of this paper are to investigate the risks of logistics outsourcing and to present related risk prevention measures.

RELATED LITERATURE

We begin with a discussion of some related literature and then examine some of the risks in logistics outsourcing.

Several recent studies have addressed the issue of growth in the 3PL market and other freight intermediaries in detail. A study by Murphy and Poist (1998) provides a review and synthesis of research on this topic.

Lieb and Peluso (2000a, 2000b) and Lieb and Randall (1997) discuss insights gained from a multi-year survey of chief executive officers of the largest 3PL providers in the United States. Key findings reported in the paper are the following: most of the companies surveyed are autonomous subsidiaries of companies in the transportation and warehousing business; most have significantly increased their international operations in the past few years; most are increasingly forming strategic alliances with other 3PL companies as well as companies primarily involved in warehousing, trucking, freight forwarding, and customs brokerage. That study followed an earlier study by Lieb (1992) that had as its focus large manufacturers, users of 3PL services. Similarly, Leahy, Murphy and Poist (1995) examined the determinants of successful third party relationships from the provider perspective. More recently, Sankaran and Charman (2000) performed an exploratory study of the effectiveness of 3PL contracts as well as the process by which buying firms purchase services.

The functions performed by 3PLs ranges considerably. According to the 2001 survey conducted by Lieb and Schwarz (2001), 3PLs provide Fortune 500 manufacturers a wide variety of services and they provide the typical user with multiple logistics services. The range of services provided by 3PLs is shown in Table I. As shown in Table I., the most used logistics functions provided by 3PLs in 2001 were: direct transportation services (61%), warehouse management/operations (59%), shipment consolidation services (49%), freight forwarding (45%), carrier selection (43%), inventory replenishment (41%), customs brokerage (41%), and carrier performance measurement (41%).

Table I The Most Frequently Provided Services

Logistics Function	Cited Use(%) 2001
Direct transportation service	61
Warehouse management	59
Shipment consolidation	49
Freight forwarding	45
Freight payment	53
Tracking/tracing	33
Customs brokerage	41
Design of IT systems	8
Selection of software	8
Operation of IT systems	20
Carrier selection	43
Rate negotiation	37
Product returns	25
Fleet management/operations	20
Relabeling /repackaging	25
Contract manufacturing	10
Order fulfillment	33
Assembly/installation	10
Inventory replenishment	4
Order processing	8
Customer spare parts	10
Consulting services	25
Purchase of materials	4

Source: Lieb and Schwarz (2001)

RISKS ANALYSIS IN LOGISTICS OUTSOURCING

The benefits of outsourcing logistics services in some cases can be considerable. For example, 3PL's have made "build to order" manufacturing systems possible in the computer industry where there would have been otherwise infeasible (Harrington, 1999). The automotive industry often relies on a third party logistics provider to perform functions associated just in time operations (Lynch, 2002). Rapidly changing markets suggest that the industry should see continued growth in the next several years. Persson and Virum (2001) identified the more frequently cited reasons for logistics outsourcing. For many companies, increasing demands for new information systems, resources and real time visibility into production and other status often can be met most efficiently through outsourcing (Lynch, 2002).

Boyson et al (1999) examined the reasons why some logistics outsourcing partnerships are successful and how best to manage a third party logistics relationship. In particular, their research identified the most effective means and methods for evaluating and selecting third party logistics providers from outsourcing users perspective, and identified the most effective means for organizing, operating, and monitoring third party logistics

relationships. Sink and Langley (1997) presented a conceptual model of the third party logistics purchasing process, which, according to their analysis, consists of five distinct steps or phases.

Analysis of the disadvantages of outsourcing has been performed over the last few years in other applications. For example, Earl (1996) examined these issues related to information technology (IT) outsourcing. Earl's perspective is based on an analysis of eleven risks of outsourcing identified in discussions with both buyers and vendors in the IT outsourcing marketplace. Barthelemy (2001) discussed the hidden costs of IT outsourcing from outsourcing users perspective. Cavalla (1996) and Piachaud (2002) presented perceived disadvantages of R&D outsourcing in pharmaceutical industry.

However, we know of no published research focusing specifically on the risks of outsourcing logistics activities. Drawing from research in other industries we explore potential risks in third party logistics. Please note that when we reference research in these other industries we are providing a reference to the main ideas examined by those researchers related to outsourcing – not referencing a discussion related specifically to logistics outsourcing.

The Possibility of Inefficient Management

If a firm has an efficient, well-managed distribution system, outsourcing that system may not reduce operating costs (Lynch, 2002). If an in-house logistics service had poor operational performance, a firm may be tempted to outsource it to a third party. If the firm selects outsourcing, the executives also have to know how to manage contracts and relationships with the third party logistics provider. If the logistics activity has been badly managed in the first place, it may not be possible for the logistics manager of the firm to be any better at managing an external provider. Once logistics outsourcing has been initiated, managing logistics operations is still difficult. In some cases there will be a need for a more professional and highly trained purchasing and contract management group (Quinn, and Hilmer, 1994). If the third party logistics provider chooses to change the way it provide logistics service, the firm has to learn about the new system. If the third party logistics provider changes its personnel or organization, the firm has to invest in establishing new partnership and understanding how things are operated in the new environment (Earl, 1996).

Latent Information Asymmetry

There exists an information asymmetry in logistics outsourcing. The third party logistics provider rarely has complete information about the contracting company; similarly the contracting company may have incomplete information about the third party logistics provider. For example, if a third party logistics provider has incomplete information about the contracting companies' cost structure, the price it will offer (and therefore its profit level) may not be well matched to that cost structure.

Loss of Logistics Innovative Capacity

If a firm has outsourced its logistics services, its logistics innovative ability may be impaired (Earl, 1996). In the long run, if a firm wants to maintain its comprehensive competitive competences, it will have new ways of providing logistics services for the business. External sourcing does not guarantee innovation. During outsourcing contract periods, the third party logistics provider may not recognize an opportunity to innovate as its focus may be primarily on costs.

Hidden Costs

Drawing on a recent study of IT outsourcing by Bartholomew (2001), which examines hidden costs, we can make the following observations about logistics outsourcing:

Benefits can be eroded by costs that firms' managers cannot identify *a priori*. Many firms underestimate the costs associated with selecting a third party logistics provider, and negotiating and drafting a contract. Additional time and expense early on helps avoid problems later, such as having to renegotiate the contract or constantly monitor the logistics provider to get the needed performance. Estimating transition costs can be very difficult. Switching in-house logistics activities to a third party logistics provider presents probably the most elusive hidden cost. Most firms do not realize how much they have spent until the transition is complete. Managing the effort probably represents the largest category of hidden costs because it covers three areas: monitoring to see that logistics providers fulfill their contractual obligations, bargaining with logistics providers, and negotiating any needed contract changes. Vendor-management costs for logistics outsourcing are not readily apparent either. Management often does not consider these costs because they only become visible when overall outsourcing costs have noticeably escalated (Barthelemy, 2001).

Dependence on the Third Party Logistics Provider

A firm that outsources its logistics activities to an third party logistics provider runs the risk of becoming dependent on that provider. By contracting out logistics activities to the same third party logistics provider over a long period of time, the firm may find itself in an increasingly vulnerable position and may even lose control of part of its logistics activities.

Loss of Control over the Third Party Logistics Provider

All collaborative projects result in some loss of control. In outsourcing arrangements, partial control of a project inevitably passes from the sponsor to the collaborator Piachaud (2002). The extent to which the firm may effectively control an outsourced logistics business will greatly determined by the information received and the early detection of problems. Since the information available to the logistics manager would be less comprehensive than it would be if the logistics business were conducted in-house, a lack of

effective communication could ensue as a result. This could lead to problems of quality and to delays, as well as to misunderstandings and even mistrust (Cavalla, 1996). Because of misunderstandings and mistrust, third party logistics providers also have to build slack into their operations. Lack of visibility of shipment and demand schedules may result in the creation of excess capacity and excess shipping expenditures. It can also lead to the use of uneconomic modes of transportation (package vs. less-than-truckload; less-than-truckload vs. truckload for example).

Problems of Evaluating and Monitoring Third Party Logistics Provider Performance

In order to properly evaluate the functions of a third party logistics provider, firms must develop clear guidelines for appraising third party logistics provider outcomes. However more often than not, this is a factor that is frequently overlooked by firms when developing a partnership with third party logistics provider.

Monitoring logistics outsourcing is often a difficult and complex task. In order to ensure that the business carried out by the third party logistics provider meets the required standards, Resources such as money, time and expertise are needed to establish an effective monitoring system.

Conflicts of Firms Culture

In logistics outsourcing arrangements, the goals of each party are often different so the factors that determine the commercial merit of the partnership are being considered from different perspectives. Management styles and degrees of bureaucracy within firms may also be different. Consideration of these factors is essential to ensure the viability of the collaborative venture and the future success of the partnership (Piachaud, 2002).

The eight aspects of risk mentioned above come in many different forms and can be classified into four categories. The first relates to financial risks. The second group relates to the “chaos” risks of logistics outsourcing, these chaos effects result from mistrust and information asymmetry. The third group relates to market risks, a firm cannot be responsive to changing market trends and customer preferences due to dependence on the third party logistics provider. The fourth group relates to management risks. (Table II)

Table II Categories of Risks in Logistics Outsourcing

Category	Aspects	Features
Financial	Hidden Cost	Many firms underestimate the costs related to selecting a third party logistics provider, and negotiating and drafting a logistics outsourcing contract.
“Chaos”	Latent Information Asymmetry	Incomplete information and moral risks resulting from asymmetric information will cause decision-making risk.
	Loss of Control over the Third Party Logistics provider	The extent to which a firm may effectively counterpart some loss of control over the third party logistics provider is greatly determined by the information received. A lack of effective communication could cause incomprehensive information and lead to problems of quality and to delays, as well as to misunderstanding and even mistrust.
Market	Loss of Logistics Innovative Capacity	A third party logistics provider does not guarantee a firm to maintain long term comprehensive competitive competencies and to have new ways of providing customized logistics services
	Dependence on the Third Party Logistics Provider	A firm may find itself in an increasingly vulnerable position and cannot be responsive to changing market environment and customer requirements.
Management	The Possibility of Inefficient Management	It is difficult for a firm to manage logistics outsourcing. In some cases there will be a need for a more professional and highly trained purchasing and contract management group.
	Problems of Evaluating and Monitoring Third party Logistics Provider performance Conflicts of Culture	Firms frequently overlook the task of appraising third party logistics provider outcomes. The goals of each party, management styles and degrees of bureaucracy within firms are different.

RISK REDUCTION

To promote the service effectiveness for firms and operations efficiency for third party logistics service providers, and to minimize the uncertainties associated with logistics outsourcing, risks reduction measures should be implemented.

Performance Indices for Logistics Outsourcing

The performance assessment indices in logistics outsourcing should include both cost and service measures. The performance assessment indices should evaluate systematically the performance of integrated third party logistics operation, reflect accurately the relationship between third party logistics providers and firms and realize effectively the integration of third party logistics providers and users.

Information Sharing Encouragement Mechanisms

The most common risks in logistics outsourcing are probably decision-making risk due to incomplete information and moral risks resulting from asymmetric information. There is typically one participant with superior information and another participant possessing inferior information. In order to avoid potential problems, information sharing encouragement mechanisms must be developed. Information technologies can be used to establish these information-sharing mechanisms which can lead to win-win situations for both participating parties. In logistics outsourcing, key operational information such as costs, demands, shipment plans, capacities, etc., should be easily accessible by both participating parties. Such information should be accurate and timely, rendering it useful to both parties for planning and re-planning purposes. Thus, it is important that information sharing encouragement mechanisms are established so that any updates are made as timely as possible.

Suitable Performance Tactic

It is important for a third party logistics provider to design a suitable third party logistics-performing tactic. Designing a suitable performance tactic, another valid measure to prevent performance risks, enables third party logistics providers to improve customer service levels and ensure that successful logistics partnership are developed. The performance tactic of a third party logistics provider should be centered on the characteristics of products or industries. Different products or industries have different requirements. In accordance with the characteristics of products or industries, there are innovative products or industries, which have high margins and unstable demands and functional products or industries, which are characterized by low marginal profit margins and more stable demands. Third party logistics performance tactics for innovative products or industries should be different from those designed for functional products or industries. Because of the difference between these two categories, different third party logistics services are needed to meet their requirements (Table III).

Table III. Matching 3PL Services and Product or Industry Needs

Product or Industry			
Third party logistics	Effective Responsive	Functional Good Match Good Match	Innovative Poor Match Poor Match

Customer Relationship Management

For logistics outsourcing arrangements to be successful they must include a strong emphasis on customer relationship management. Here customer relationship management is different from what we typically think of as customer service. Relative to customer relationship management, traditional customer service is passive. Customer service actions are initiated by customers presenting requirements, whereas, customer relationship management is active, not only solving problems but also maintaining close contacts. Customer relationship management seeks to develop strong and lasting ties to customers by anticipating their needs rather than simply reacting to their dissatisfaction. Customer relationship management tries to provide a unified view of a customer across the firm by integrating the firm's customer-relations process and consolidating customer information from multiple communication channels so that the firm can provide a single coherent face to the customer (Laudon and Laudon, 2002). Customer relationship management relies on the integration of marketing and logistics customer service, and regards customer service as another marketing mode. Therefore, customer relationship management is sometimes referred to as "backstage marketing".

Advanced customer relationship management aims at reducing logistics service costs, increasing gains, strengthening customer relation, increasing customer satisfaction and loyalty, improving information quality, reducing information transmission delays and simplifying customer service processes.

CONCLUSIONS AND IMPLICATIONS

The third party logistics industry has become relatively stable in the US and in Europe. However, it is a rapidly growing and emerging industry in Asia. Successful logistics outsourcing can provide significant benefits to firms and to third party logistics providers. However, there are some hidden risks in logistics outsourcing. Identifying hidden risks and preventive measures can help build successful logistics outsourcing partnerships.

Implications for Managers

Though our research should be considered only preliminary, our paper analyzes the main risks caused by logistics outsourcing, and presents four important measures for avoiding risks in logistics outsourcing. Third party logistics providers wishing to improve their services need to constantly monitor their performance and to build successful logistics partnerships. The measures suggested in this paper can be used as a self-analytic tool to identify areas where specific measures are necessary.

Implications for Researchers

There exists a wide scope for future research on the risks prevention issues of logistics outsourcing. The risks prevention measures are presented in this paper only in conceptual level. On-going research is focused on quantitative analysis of the relationships between these measures. Some conceptual models of the risks prevention measures are also needed. Future research should have the following objectives: to present decision-making analysis on in-house or outsourcing logistics from the users perspective; to examine the decision-making model on selection of a third party logistics provider; to identify the evaluation criteria for logistics outsourcing partnerships from the integrated outsourcing relationship perspective; to build up the model of logistics outsourcing coordination under information asymmetry.

REFERENCES

- Barthelemy, J. (2001), "The Hidden Costs of IT Outsourcing", *Sloan Management Review*, Spring 2001, 42(3): pp 60-69.
- Boyson, S. T. Corsi, M. Dresner, and E. Rabinovich (1999), "Managing Effective Third Party Logistics Relationships: What Does It Take?" *Journal of Business Logistics*, 20(1), pp 73-100.
- Cavalla, D.(1996). *Modern Strategy for Pre-clinical Pharmaceutical R&D: Towards the Virtual Research Company*, Wiley, Chichester.
- Economist (2002), "A Moving Story", December 5, 2002.
- Earl, M. J. (1996), "The Risks of Outsourcing IT", *Sloan Management Review*, Spring 1996, 37(3) pp 26-32.
- Foster. T.A. (1999), "3PLs Serve up Supply Chain Innovation, *Logistics Management & Distribution Report*", 38(7), pp 65.
- Gooley, T. B. (2002), "Two Sides of the same 3PL Coin", *Logistics Management & Distribution Report*, 41(2), pp 45-49.
- Harps, L.H. (2001), "Selecting 3PL Partners", www.inboundlogistics.com.
- Harrington, L. H. (1999), "Win Big with Strategic 3PL Relationships", *Transportation & Distribution*, 40 (10), pp118-126.
- Lambert, D. M., M.A. Emmelhainz, J.T. Gardner (1999), "Building Successful Logistics Partnerships", *Journal of Business Logistics*, 20(1) pp 165-181.
- Laudon K.C and J. P. Laudon (2002), *Management Information Systems-Managing The Digital Firm*, Prentice Hall, pp 53.
- Leahy, S.E, P.R. Murphy and R.F. Poist (1995), "Determinants of Successful Logistical Relationships: A Third-Party Provider Perspective", *Transportation Journal*, 35 (2), pp 5-13.
- Lieb, R.C. (1992), "The Use of Third Party Logistics Services by Large American Manufacturers", *Journal of Business Logistics*, 13 (2), pp 29-42.
- Lieb, R.C. and B. Schwarz (2001), "The Use of Third Party Logistics Services by Large American Manufacturers, The 2001 Survey", Working Paper, Northeastern University.
- Lieb, R.C. and H. L. Randall (1997), "CEO Perspectives on the Current Status and Future Prospects of the Third Party Logistics Industry in the United States", *Transportation Journal*, 38 (3), pp28-41.
- Lieb, R.C. and L. Peluso (2000a), "1999 CEO Perspectives on the Current Status and Future Prospects of the Third Party Logistics Industry in the United States", working paper, Northeastern University.
- Lieb, R.C. and L. Peluso, (2000b), "The Use of Third Party Logistics Services by Large American Manufacturers", the 1999 survey, working paper, Northeastern University.
- Lynch, C. F (2002), "Price vs. value: The Outsourcing Conundrum", *Logistics Management & Distribution Report*, 41(2), p 35.
- Mckinnon, Alan C.(1999), "The outsourcing of Logistical Activities", working paper, Heriot-Watt University (Edinburgh).
- Mercer Management Consulting, (2002), "Chinese 3PL Market Development Trends", www.56.net/news (Chinese language document).

- Murphy, P. R and R.F. Poist, (1998), "Third-party logistics usage: An assessment of Propositions Based on Previous Research", *Transportation Journal*, 37 (4), pp 26-35.
- Persson, G. and H. Virum (2001) "Growth Strategies for Logistics Service Providers: A Case Study", *International Journal of Logistics Management*, 12(1), pp 53-64.
- Piachaud B.S. (2002), "Outsourcing in the Pharmaceutical Manufacturing Process: an Examination of the CRO Experience", *Technovation*, 22(2), pp 81-90.
- Quinn, J.B. and F.G. Hilmer (1994), "Strategic Outsourcing", *Sloan Management Review* 35 (4), pp 43-55.
- Sankaran J., and Z. Charman (2000), "An Inductive Empirical Investigation into Third Party Logistics Contracts", Institute of Transport Studies, University of Sydney, working paper, ITS-WP-00-08.
- Sink, H.L., J.C. Langley Jr. (1997), "A Managerial Framework for the Acquisition of Third Party Logistics Services", *Journal of Business Logistics*, 18 (2), pp 163-189.
- Xie, P. (2001), "Where is the Barrier to Third Party Logistics?" Available from www.chinawuliu.com.cn/papers/content/2001-3-02-03.asp .