Trade-offs in Multimodal Transport Options: The Case of Logs Carriage from U.S. to South Korea

Dong-Wook Kwak* and Young-Joon Seo**

ABSTRACT

This study aims to explain the concept of multimodal transport and to provide the motives of and key trade-offs in utilising multimodal transport. To demonstrate these, a case study as a main methodology, carriages of logs from the U.S. to South Korea, was analysed by the "UNCTAD Cost Model". By doing so, this study clarifies motives and trade-offs of multimodal transport with a real case. The finding of this study suggests that optimised use of multimodal transport with consideration of their trade-offs can enhance shippers' competitiveness in globalised circumstances. Besides, this finding can help the managers of multimodal transport companies to minimise the transport costs and time in the transportation of log carriages between U.S. and South Korea.

Keywords: multimodal transport, logistics, international transport, inter-modalism, logs carriage

* First author, School of Strategy and Leadership, Coventry University, United Kingdom, d.kwak@coventry.ac.uk

** Corresponding author, International Shipping and Logistics Group, Plymouth Business School, Plymouth University, United Kingdom, Y.Seo@plymouth.ac.uk

1. Introduction

"Multimodal transport" means by itself transport by many modes because "multi" originated from a Latin word meaning "many." This term was given an authorised definition by United Nations Convention on International Multimodal Transport of Goods 1980, which states that "International multimodal transport means the carriage of goods by at least two different modes of transport on the basis of a multimodal transport contract from a place in one country at which the goods are taken in charge by the multimodal transport operator to a place designated for delivery situated in a different country (United Nations, Part 1, Art 1, Para 1)." Therefore, the main characteristics of a multimodal transport from this definition are: (1) carriage of goods by at least two different modes, (2) under one contract, (3) one document and (4) one responsible party, multimodal transport operator (UNCTAD, 2001). However, the convention has not entered into force yet even though International Chamber of Commerce (ICC) and FIATA accepted this terminology in UCP 500 and in global liability standards respectively (Wong, 1997).

According to Wong (1997), there are slight differences in definitions between multimodal transport and its synonyms such as 'Through Transport,' 'Combined Transport' and 'Intermodal Transport' from legislative perspectives. Firstly, through transport bears using a single mode in a unitised movement. This was defined by HMSO (1966, p. 1) as "the methods of distribution and transport which give through flow of traffic, from the point of origin to the final point of destination, with minimum transshipment and delay". Secondly, combined transport is delineated as the carriage of goods by at least two different modes of transport, from a place at which the goods are taken in charge situated in one country to a place designated for delivery situated in a different country, according to ICC Uniform Roles for Combined Transport Document Rule 2a. It has a minimum/maximum distance for each leg while indicating no universal liability; EU's directorate DG7 (EU's COM(92) 230 final, Brussels, 11 June 1992) restricts the minimum distance to 600km and the feeder's maximum distance to 150km. Thirdly, intermodal transport is associated with intermodal transfer, in particular, with international container traffic, thus goods are not double-handled each time of transshipment (Department for Transport, 2008).

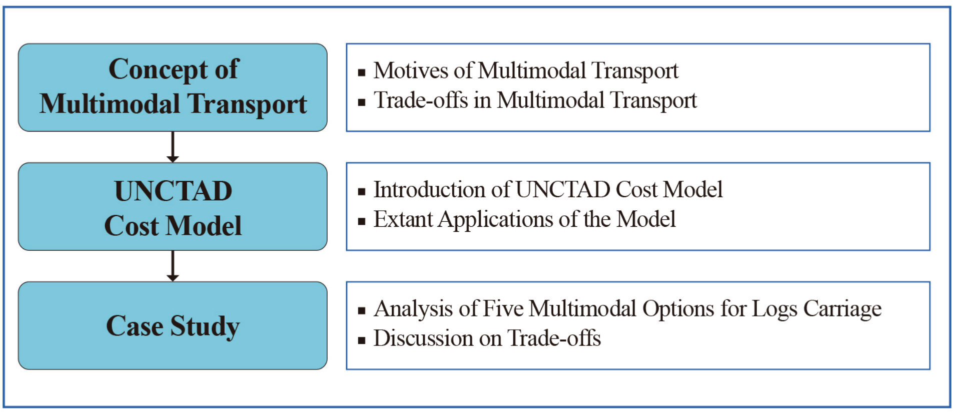
In practice, however, those terminologies seem to be used in a mixed manner. Although world top 10 liner shipping companies provide door-to-door service, they use different B/L terms for the service according to author's investigation (Table 1). In the research field, few distinctive features are identified among those terms, in particular, between multimodal transport and intermodal transport. Bontekoning et al. (2004) summarised diverse definitions of intermodal transport represented in studies of rail-truck intermodal transport (Appendix A), but the definitions of intermodal transport tend to overlap with that of multimodal transport. Specifically, the definition of intermodality presented by Hayuth (1987) consists of (1) movement of cargo by at least two different modes of transport, (2) under a single rate, (3) under through billing, and (4) under through liability, which is almost the same as the UN Convention's definition of multimodal transport.

Table 1. Terminologies used by shipping lines

B/L Term	Shipping Lines
Multimodal Transport	Maersk, CMA-CGM
Intermodal Transport	COSCO, Hanjin
Through Transport	Evergreen
Combined Transport	MSC, APL, CSCL, MOL, OOCL

Sources: Adapted from each carrier's website

The majority of long-haul freight transport is operated in multimodal ways with development of unitisation and transshipment. Economic globalisation, speed-to-market product delivery, agile manufacturing and business practices and integrated supply chain management are major trends driving demand of multimodal transport (Rondinelli and Berry, 2000). Therefore, this study aims to explain the concept of multimodal transport and to provide the motives of and key trade-offs in utilising multimodal transport. To demonstrate these, a case study, carriages of logs from the U.S. to Korea will be analysed by the "UNCTAD Cost Model". Despite a large number of extant case studies on the multimodal transport, no study pertaining to carriage of logs has been conducted. Logs and lumber is one of the biggest items, in a trade volume term, imported from the U.S to South Korea, which can be transported by various transport options and routes. In this circumstance, analysing and comparing different multimodal transport options would be beneficial to Korean importers who consider the cost- and time-efficient ways of international transport.



Source: Authors

Figure 1. Outline of this study

2. Multimodal choice

Shippers, consignees, and multimodal transport operators strive to choose optimised transport solutions with their own criteria and factors. Long distance transport adds various options to their choice. According to McKinnon (1989), factors influencing a freight modal choice are divided into traffic-related, consignor-related and service-related factors, and each category has several sub-factors (Table 2), which are also valid when analysing multimodal choices. Based on Table 2, (1) motives of multimodal choice in long-haul transport, (2) trade-offs between multimodal and unimodal, and (3) trade-offs between modes are reviewed.

Table 2. Factors affecting freight modal choice

Traffic-related	Consignor-related	Service-related
Length of haul	Size of firm	Speed (transit time)
Consignment weight	Investment priorities	Reliability
Dimensions	Marketing strategy	Cost
Value	Spatial structure of production	Product care
Value density	and logistical system	Customer relations
Urgency	Availability of rail siding	Geographical coverage
Regularity of shipment	Stockholding policy	Accessibility
Fragility	Management structure	Availability of special vehicles/
Toxicity	System of modal/carrier evaluation	handling equipment
Perishability		Monitoring goods in transit
Type of packaging		Unitisation
Special handling characteristics		Provision of ancillary services
		Computing facilities/compatibility
		Accuracy of documentation

Sources: Mckinnon (1989)

2.1 *Motives of multimodal transport*

One motive for using multimodal transport is geographical coverage and accessibility of a mode. As transit distance becomes longer, geographical impediments emerge. Oceans, high mountains and closed borders can be the examples. Long-haul transport is constrained by geography, which leads shippers to choosing the best way to overcome this problem. In the research of multimodal transport of iron ore from Australia to China, for instance, Beresford et al. (2006d) investigated six possible multimodal routes, but all of whose first two modes were rail and sea due to geographical reasons. In a similar vein, UNESCAP (2006) researched transport system in North-East Asia linking Busan, Korea to Beijing, China by rail, but the only practical availability is via Yellow Sea because this linkage was subject to open-border of North Korea. Accessibility often makes trucks as the mode for the first and the last legs even though other transport modes are selected for the main leg due to geographical reasons. Transshipment is required at the margin of the geographical coverage of a certain mode, therefore long-haul transport shows multimodal characteristics.

Another important motive is minimisation of transport cost. It is inevitable that shippers should select a mode with the lowest cost per kilometer per unit for long haul transport. Normally, the greater the volume one mode can accommodate, the less the freight cost is. This is because of economies of scale which lower average fixed cost considerably. Thus, in the same route, 10,000 TEU vessels can provide a lower rate than 300 TEU double-stack trains, and a much lower rate than trucks which can load 2 TEUs at once. As accessibility restricts the first and the last modes to trucks, long-haul transport will be multimodal with at least one cheaper mode. Coordination of different modes is critical to cost-efficient international transport (United Nations, 2003).

Long distance transport is required to choose a mode with the least costs per distance to minimise overall transport costs despite incurring some transshipment costs. Although the transshipment will increase the costs without changes in any distance, it can be an economic choice. In a case study of freight movement on the UK-Greece Corridor, Beresford (1999) compared unimodal truck movement cost to other multimodal alternatives' costs. While unimodal transport cost from London to Athens reached GBP 2,971, the cheapest multimodal option cost only GBP 819 even including transshipment costs, largely due to low freight costs of rail and Ro-Ro ferry. Transshipment costs, however, cannot be bearable in short-haul transport because they will take up an enormous proportion of entire costs.

2.2 Trade-offs: multimodal vs. unimodal

Firstly, transport costs and transshipment costs matter. Multimodal transport can choose economical modes but should accept the burden of transshipment costs. In contrast, unimodal transport is free from transshipment costs but should often accept higher transport cost. In this circumstance, transshipments costs can often be a key to overall transport costs. In the research of Banomyong and Beresford (2001), the costs of multimodal transport from Vientiane (road) via Lad Krabang ICD (rail) to Laem Chabang Port were almost the same as that of unimodal transport from Vientiane (road) to Laem Chabang because reduction of transport costs were offset by transshipment costs. If the haulage is long enough, however, multimodal transport tends to obtain more benefits. Secondly, transit time controllability should be considered. If one mode is used, transit time can be easily calculated and the schedule is sufficiently guaranteed. Although multimodal transport may shorten transit time using a faster mode, it cannot escape from transshipment time, which normally adds uncertainty. Also, differences in speed between modes may aggravate the uncertainty. Thirdly, cargo reliability should be taken into consideration. Loss of or damage to the cargo is particularly important when cargo is perishable or valuable. As for reefer cargoes, long road haulage is recommended due to less delay and cargo controllability even though the cost is more expensive (Beresford et al., 2006a).

2.3 Trade-offs: mode vs. mode

In general, trade-offs originate from cost versus service, and service can be divided into more specific elements such as transit time and inventory level. Cost versus transit time is the most typical but significant trade-off in long-haul transport. In particular, this trade-off can be well represented by the different characteristics of ocean transit and air transit: the advantage of one mode is the disadvantage of another mode, as shown in Table 3. Also, various combinations of modes can create different cost-transit time pairs. The majority of case studies on multimodal choices refer to these elements as the main trade-offs (Table 4).

Transport cost affects inventory in two ways. Firstly, a common but indirect effect is that the transit speed affected by cost can considerably reduce inventory cost. In other words, to cut inventory cost through shorter lead time, shippers should select a faster but more costly mode. Secondly, a direct effect is that lower transport cost usually stems from economies of scale, which means that batch size should be large. A large batch requires inventory costs such as storage places, management costs, and even risks of obsolescence.

Table 3. Generic assessment of the qualities of different modes

	Road	Rail	Waterway	Air
Cost	High	Low	Very Low	Very High
Speed	High	Low	Low	Very High
Door to door capability	Very High	Low	Very Low	Low
Reliability	Very High	High	High	Very High
Security	Very High	High	High	Very High
Safety	Safe	Very Safe	Safe	Very Safe
Flexibility	Very High	Low	Low	Low
Availability	Very High	Low	Very Low	Low

Sources: Adapted from Beresford et al. (2007)

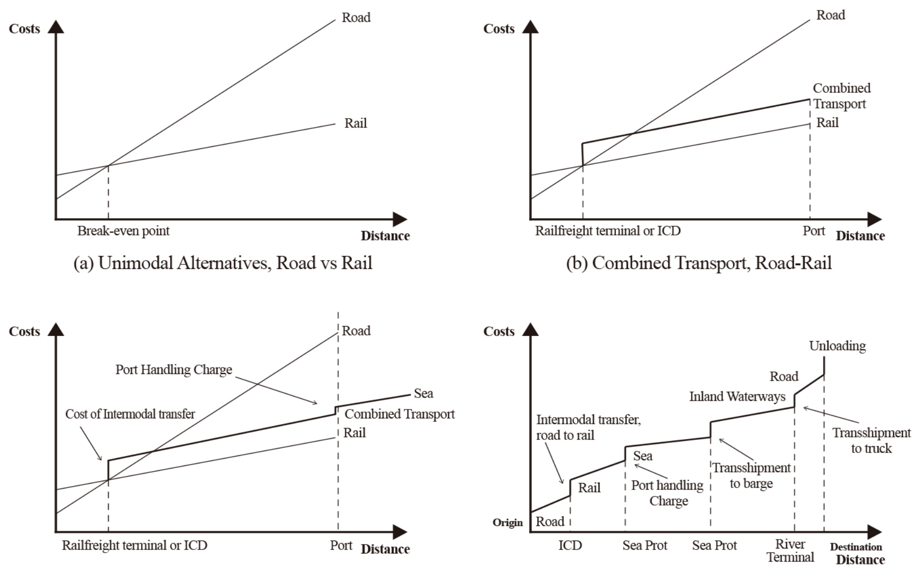
Table 4. Case studies on multimodal transport using UNCTAD cost model

Supply Chain	Product	Principal Modes	Source
Scotland - Greece	Whisky	Road / Sea /Road	Beresford (1999)
Lao PDR - EU	Garments	Road / Sea /Road	Banomyong and Beresford (2001)
New Zealand - China	Dairy Product	Road / Sea /Road	Beresford et al. (2006a)
Taiwan - China	Flowers	Road / Sea / Waterway	Beresford et al. (2006b)
Eire - China	ATMs	Air / Sea-Air / Road	Beresford et al. (2006c)
Australia - China	Iron Ore	Rail / Sea / Road, Rail	Beresford et al. (2006d)
France - South Africa	Containerised	Road /Waterway / Sea	Beresford et al. (2007)

Sources: Beresford et al. (2007)

3. Methodology

As international trade volume increases and multimodal transport becomes vital, multimodal choice became critical to the success of international trade (Min, 1991). To aid multimodal transport users' decision making, development of cost models for multimodal transport has been attempted by many researchers (Hayuth, 1986; Marlow and Boerne, 1992; Min, 1991; Yan et al., 1995). "UNCTAD Cost Model" initially adopted by Beresford and Dubey (1990) and improved by Beresford (1999) demonstrates essences of multimodal choices concerning cost, distance, time, modes and nodes. This model starts from a simpler comparison between modes (Figure 2a) and expands to a final mature form involving various modes and nodes (Figure 2d). The model not only provides graphical comparison between multimodal choices but also emphasises cost and time in multimodal transfer. In multimodal transport, loading, discharging, storage and transshipment should be added to transport process (Van Schijndel and Dinwoodie, 2000), and cost of each process should be also considered. In this model, while the slopes mean transport cost per distance, vertical surges show cost steps of multimodal transfer. With excellences in explanatory merits, this model was adopted as the UN's standard approach to assessing the effectiveness of international transport (Beresford et al., 2007; United Nations, 2003; UNESCAP 2006). This work will also use the UNCTAD Cost Model as an analytical tool.



(a) Unimodal Alternatives, Road vs Rail

(b) Combined Transport, Road-Rail

(c) Combined Transport, Road-Rail-Sea

(d) Multimodal Transport, from Origin to Destination

Source: Banomyong and Beresford (2001)

Figure 2. UNCTAD model for multimodal freight transport

4. A case study: logs carriage from the US to Korea

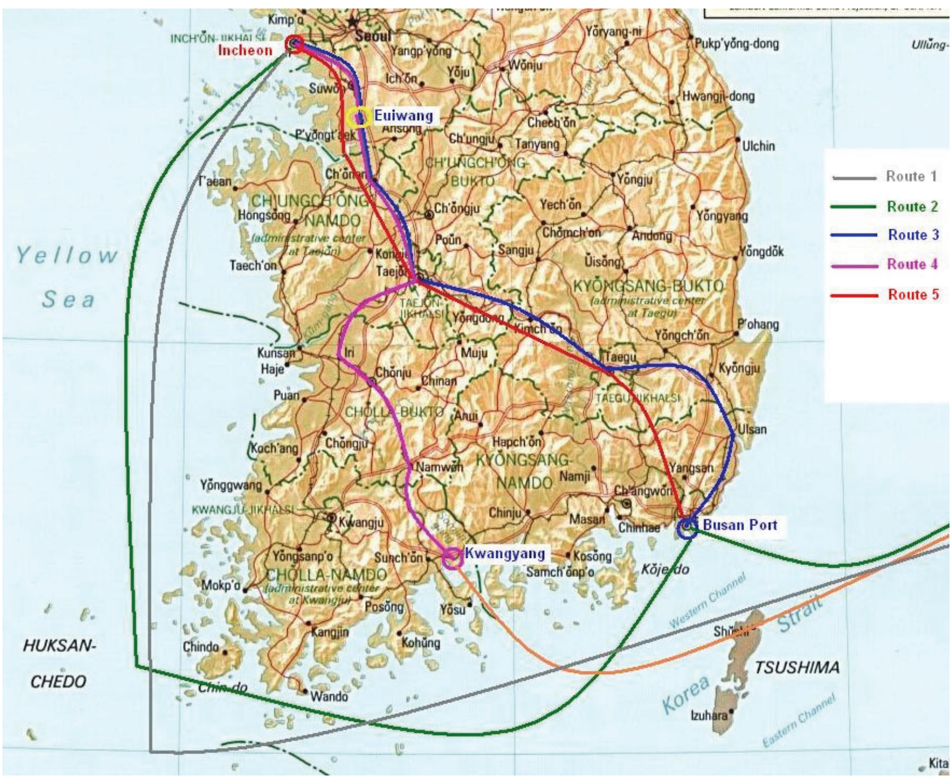
4.1 Background

Korea's demand for logs is largely dependent upon import from New Zealand, Russia, Australia and the U.S. In particular, the proportion of the U.S. is vital. Although logs are generally moved by specialised log carriers or bulk carriers, but one interesting characteristic of U.S. export is that containerised transport is also viable. This is largely due to trade imbalance between Trans-Pacific westbound and eastbound which results in container freight rate reduction for westbound cargoes. Moreover, container service offers competitive rate against its substitute, bulk service, to induce log shipment.

In specific, this study investigates transport from Seattle, U.S. to Incheon, Korea because Incheon has the largest wooden product manufacturing cluster but with no direct liner service from the U.S. In this situation, the importers can choose either bulk carriage or container carriage for Trans-Pacific and can consider multimodal transport within Korea. This case study has a value because a few studies have researched minor container bound like Pacific westbound and also because there were few studies on direct comparisons between bulk and container carriage as multimodal routes. For transport by dry bulk vessels, it is assumed that the logs will be carried by a time charter of 27,000 dwt geared vessel. The container shipping is assumed to be subject to a service contract with minimum quantity of 1,000 FEU per annum (24 tons per FEU).

4.2 Analysis on each route

Multimodal transport routes from Seattle, U.S. to Incheon, Korea can be summarised as Table 5 and graphically illustrated in Figure 3. As the cost/distance/time from lumber mills to Seattle port is common in all routes, this study concerns the transport from Seattle Port.



Source: Authors

Figure 3. Routing options in Korea

Table 5. Routing options from Seattle, US to Incheon, Korea

Route	Origin	Mode	Transfer	Mode	Transfer	Mode	Destination
1	Seattle (US)	Bulk Vessel	Incheon (Korea)	Truck	-	-	Incheon (Korea)
2	Seattle (US)	Container Vessel	Busan (Korea)	Feeder Vessel	Incheon (Korea)	Truck	Incheon (Korea)
3	Seattle (US)	Container Vessel	Busan (Korea)	Rail	Euiwang (Korea)	Truck	Incheon (Korea)
4	Seattle (US)	Container Vessel	Gwangyang (Korea)	Rail	Euiwang (Korea)	Truck	Incheon (Korea)
5	Seattle (US)	Container Vessel	Busan (Korea)	Truck	-	-	Incheon (Korea)

Route 1 is a traditional logs carriage route using bulk or logs carriers. As the vessel can discharge cargoes at Incheon Port, sea leg is maximised (99.87%) and road is minimised (0.13%). However, sea leg occupies only 65% of total cost, while costs incurred at both ports reach 29%. As bulk carriers are not speedy and loading/discharging time is considerable, total transit time is the longest, 34 days. One hidden cost is that importers should bear both financial costs to open L/C for several thousand tons of cargo and inventory costs accumulated until all cargo is depleted.

Route 2, a sea-maximised container route, is the most preferred route by importers among container movement because of the shortest road transport. In this route, the distance of sea leg comprises of 99.88% of entire distance but costs only 71%. In contrast, terminal handling charges and transshipment costs occupies 22%. The transit time is 3rd highest but cost is the cheapest among container transportation. Compared to bulk transport, there is still a cost gap but transit time can be significantly shortened.

Route 3 and Route 4 utilise similar routes but discharging ports decide the differences in cost and transit time. Compared to Busan, Gwangyang has price competitiveness but time inferiority. Sea leg represents 61% and 63% of total costs respectively, whereas distance proportion is reduced to approximately 94% as proportion of surface transport increases.

Route 5 maximises road haulage, which is the main reason for the highest cost. In this route, sea leg covers 94% of distance but takes only 54% of total costs, while 33% of cost is incurred by road transport. However, this route can minimise transit time to 14 days and can provide flexibility of delivery schedule.

Table 6. Analysis on cost and distance of each route

Route 1

Day	Leg	Mode	Time	Distance (Km)	Cost/Ton (USD)
1	Seattle Port	-	5 days	0	6.0
6	Seattle - Incheon	Bulk Vessel	20 days	8,095	33.3
26	Incheon North Port		9 days	0	9.0
34	Incheon (Dest)	Truck	1 hour	10	3.1
	Total		34 days	8,105	51.4

Route 2

Day	Leg	Mode	Time	Distance (Km)	Cost/Ton (USD)
1	Seattle Port	-	2 days	0	1.3
3	Seattle - Busan	Container Vessel	9 days	7,435	40.0
12	Busan Port	-	3 days	0	5.3
15	Busan - Incheon	Feeder Vessel	1 days	755	5.9
16	Incheon Port	-	1 days	0	3.5
17	Incheon (Dest)	Road	0.5 hour	10	3.2
	Total		17 days	8,200	59.2

Route 3

Day	Leg	Mode	Time	Distance (Km)	Cost/Ton (USD)
1	Seattle Port	-	2 days	0	1.3
3	Seattle - Busan	Container Vessel	9 days	7,435	40.0
12	Busan Port	-	2 days	0	8.3
14	Busan - Euiwang	Rail	8 hours	420	8.2
14	Euiwang ICD	-	6 hours	0	2.6
15	Incheon (Dest)	Road	2 hours	40	5.0
	Total		15 days	7,895	65.3

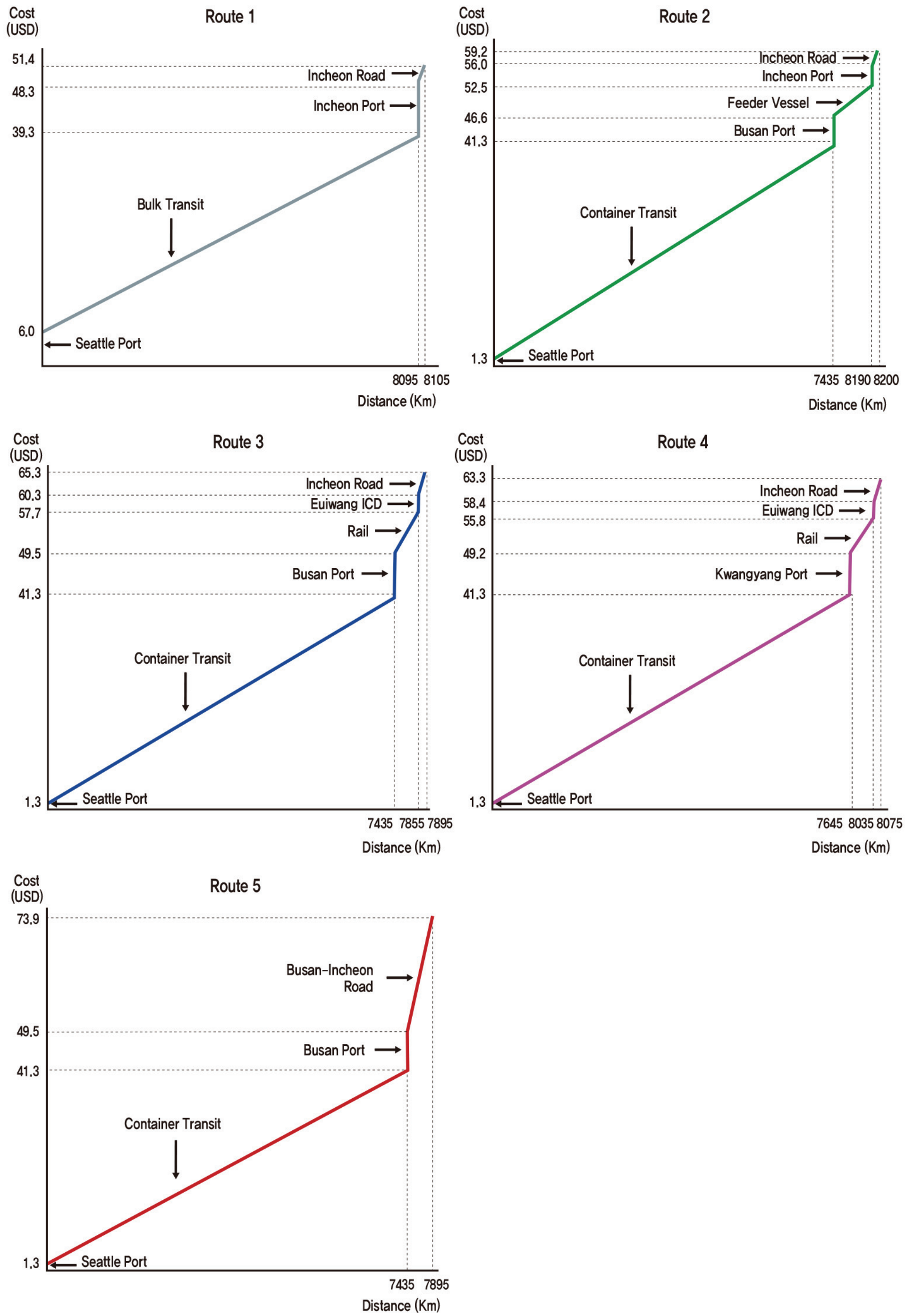
Route 4

Day	Leg	Mode	Time	Distance (Km)	Cost/ton (USD)
1	Seattle Port	-	2 days	0	1.3
3	Seattle - Kwangyang	Container Vessel	13 days	7,645	40.0
16	Gwangyang Port	-	2 days	0	8.0
18	Gwangyang - Euiwang	Rail	10 hours	390	6.5
18	Euiwang ICD	-	6 hours	0	2.6
19	Incheon (Dest)	Road	2 hours	40	5.0
	Total		18 days	8,075	63.3

Route 5

Day	Leg	Mode	Time	Distance (Km)	Cost/Ton (USD)
1	Seattle Port	-	2 days	0	1.3
3	Seattle - Busan	Container Vessel	9 days	7,435	40.0
12	Busan Port	-	2 days	0	8.3
14	Incheon (Dest)	Road	9 hours	460	24.4
	Total		14 days	7,895	73.9

Source: Authors



Source: Authors

Figure 4. Analysis on cost and distance of each route

5. Main findings and concluding remarks

The analysis of this case study is closely related to multimodal choice demonstrated in section 2. Above all, geographical coverage and accessibility limit Trans-Pacific carriages of logs to multimodal transport with sea leg partly because air transport cannot be an option due to heavy but invaluable cargo characteristics. Moreover, cost affects various combinations of transport modes. When transport within Korea is concerned, unimodal truck haulage cannot compete with feeder + road or rail + road combinations. Also, comparing bulk carriages with container carriages, it is derived that a mode selection for long distance transport is a decisive factor for cost competitiveness.

Trade-offs in multimodal transport are more clarified by the comparisons of route pairs (Table 7). Firstly, Route 3 and 5 show trade-offs in between transport and transshipment costs. Although transshipment costs arise at Euiwang ICD, rail haulage can considerably decrease transport costs. Also, this pair highlights the cargo safety aspect. Transshipment amplifies risks of cargo damage, so disrupts a safe cargo flow. Even though logs are not delicate cargoes, extra loading and discharging may cause either damage to cargo or to containers and other equipment. Transit time controllability can be weakened at nodes because delay and congestion cannot be predicted easily. Secondly, Route 1 and 5 are located on the each extreme of cost and transit time, which evidences a general notion that expensive modes provide shorter transit time. Bulk transit is much cheaper but slower, while container transit followed by road haulage is the most expensive but the fastest. Lastly, Route 1 and Route 2 demonstrate trade-off related to inventory level. Route 1 is the most cost-effective way achieved by economies of scale. But once 27,000 tons of cargoes are discharged, importers face storage and distribution problems. In this case, container transit, despite slightly higher price, can be an alternative because it moves only about 24 ton per a FEU.

Table7. Trade-offs between routes

	Trade-offs	Example
Trade-offs : Multimodal vs Unimodal	Transport-Transfer costs	Route 3 vs. Route 5
	Transit Time Controllability	Route 3 vs. Route 5
	Cargo Safety	Route 3 vs. Route 5
Trade-offs : Between Modes	Cost vs. Transit Time	Route 1 vs. Route 5
	Cost vs. Inventory Level	Route 1 vs. Route 2

Source: Authors

Despite diversified terminologies used, multimodal transport has become an effective approach to cost reduction and service improvement. In particular, long distance transport has motives to select multimodal transport in light of geographical coverage, accessibility and transport cost. As there are trade-offs in (1) between multimodal and unimodal, and (2) between different modes, multimodal choices should be carefully decided. The UNCTAD Cost Model can provide a powerful analytical tool for these multimodal choices. The model was also applied to an empirical case study of carriages of logs from the U.S. to Korea, which clarified motives and trade-offs of multimodal transport. Optimised use of multimodal transport with consideration of their trade-offs will enhance shippers' competitiveness in globalised circumstances. Despite this study's novelty, it may be worthwhile to investigate how to select the best routes by including qualitative analyses such as an expert interview as the future research.

References

Banomyong, R. and Beresford, A.K.C. 2001. "Multimodal Transport: The Case of Laotian Garment Exporters" *International Journal of Physical Distribution & Logistics Management*, Vol. 31, No. 9. pp. 651-672.

Beresford, A.K.C. and Dubey, R.C. 1990. "Handbook on the Management and Operation of Dry Ports." UNCTAD, Geneva.

Beresford, A.K.C. 1999. "Modelling Freight Transport Costs: A Case Study of the UK-Greece Corridor." *International Journal of Logistics: Research and Applications*, Vol. 2, No. 3, pp. 229-246.

Beresford, A.K.C., Qu, W., Pettit, S.J. 2006a. "Multimodal Transport Efficiency: Milk Products from New Zealand to China, Proceedings of International Conference on Logistics and Supply Chain Management." Hong Kong, January 2006.

Beresford, A.K.C., Zhang, C., Pettit, S.J. 2006b. "Multimodal Transport: A Case Study of the Taiwan – Mainland China Corridor." IAME Conference 2006, Melbourne, July 2006.

Beresford, A.K.C., Ma, P.P., Pettit, S.J. 2006c. "Multimodal Transport Utilising the Maritime Mode: A Case Study of Freight Transport from Ireland to China." Maritime Transport 2006, Barcelona, May 2006.

Beresford, A.K.C., Liu, Y., Pettit, S.J. 2006d. "Multimodal Transport of Iron Ore in Northeast China." IAME Conference 2006, Melbourne, July 2006.

Beresford, A.K.C., Zhou, Z.B., Pettit, S.J. 2007. "Multimodal Transport of Unit Load Shipments between France and South America: Cost and Modal Choice Decision Making." IAME Conference 2007, Athens, July 2007.

Bontrkoning, Y.M., Macharis, C., Trip, J.J. 2004. "Is a New Applied Transportation Research Field Emerging? – A Review of Intermodal Rail-Truck Freight Transport Literature." Transportation Research Part A, Vol. 38, No. 1, pp. 1-34.

Department for Transport (2008) Freight Best Practice: Choosing and Developing a Multi-modal Transport Solution, HMSO.

Hayuth, Y. 1987. "Intermodality: Concept and Practice." Lloyds of London Press: London.

HMSO (1966) Transport to Europe.

Korea International Trade Association, Statistics, <URL: http://stat.kita.net>.

Marlow, P.B. and Boerne G.L. 1992. "The Case for Inter-modalism in Freight Transport." Occasional Papers No. 4, Department of Maritime Studies and International Transport, Cardiff University.

McKinnon, A. 1989. Physical Distribution System, Routledge: London.

Min, H. 1991. "International Intermodal Choices via Chance-Constrained Goal Programming." Transportation Research Part A, Vol. 25, No. 6, pp. 351-362.

Rondinelli, D. and Berry, M. 2000. "Multimodal Transportation, Logistics, and the Environment: Managing Interactions in a Global Economy." *European Management Journal*, Vol. 18, No. 4, pp. 398-410.

UNCTAD. 2001. Implementation of Multimodal Transport Rule (UNCTAD/SDTE/TLB/2)

UNESCAP. 2006. Integrated International Transport and Logistics System for North-East Asia, New York.

UNESCAP, Cost/Time-Distance Methodology for Analysing Transit Transport Routes, <URL: http://www.unescap.org/ttdw/common/TFS/ImprovingTx/ESCAP_Methodology.pdf>.

United Nations. 1980. Convention on International Multimodal Transport of Goods.

United Nations. 2003. Transit Transport Issues in Landlocked and Transit Developing Countries, New York.

Van Schijndel, W.-J. and Dinwoodie, J. 2000. "Congestion and Multimodal Transport: a Survey of Cargo Transport Operators in the Netherlands." *Transport Policy*, Vol. 7, pp. 231-241.

Wong, A.K. 1997. "The Development of Multimodal Transport Systems in China." Unpublished PhD Thesis, University of Wales Cardiff.

Yan, S., Bernstein, D., Sheffi, Y. 1995. "Intermodal Pricing Using Network Flow Techniques." *Transportation Research Part B*, Vol. 29, No. 3, pp. 171-180.

Appendix A. Various definitions of intermodal transport in research field

Authors	Definition
Jones et al. (2000)	The shipment of cargo and the movement of people involving more than one mode of transportation during a single, seamless journey
Southworth and Peterson (2000)	Movement in which two or more different transportation modes are linked end-to-end in order to move freight and/or people from point to origin to point of destination
Min (1991)	The movement of products from origin to destination using a mixture of various transportation modes such as air, ocean lines, barge, rail, and truck
Van Schijndel and Dinwoodie (2000)	The movement of cargo from shipper to consignee using two or more different modes under a single rate, with through billing and through liability (Hayuth, 1987)
D'Este (1995)	A technical, legal, commercial, and management framework for moving goods door-to-door using more than one mode of transport
TRB (1998)	Transport of goods in containers that can be moved on land by rail or truck and on water by ship or barge. In addition, intermodal freight usually is understood to include bulk commodity shipments that involve transfer and air freight (truck–air)
Ludvigsen (1999)	The movement of goods in the same load-carrying unit, which successively use several transport modes without handling of goods under transit
Tsamboulas and Kapros (2000)	The movement of goods in one and the same loading unit or vehicle, which uses successively several modes of transport without handling the goods themselves in changing modes (European Commission, 1997)
Van Duin and Van Ham (1998)	The movement of goods in one and the same loading unit or vehicle, which uses successively several modes of transport without handling the goods themselves in changing modes (European Conference of Ministers of Transport, 1993)
Murphy and Daley (1998)	A container or other device which can be transferred from one vehicle or mode to another without the contents of said device being reloaded or disturbed (Jennings and Holcomb, 1996)
Newman and Yano (2000a,b)	The combination of modes, usually ship, truck or rail to transport freight
Taylor and Jackson (2000)	The co-ordinated transport of goods in containers or trailers by a combination of truck and rail, with or without an ocean-going link (Muller, 1995)
Slack (1996)	Unitised loads (containers, trailers) that are transferred from one mode to another

Source: Bontekoning et al. (2004)