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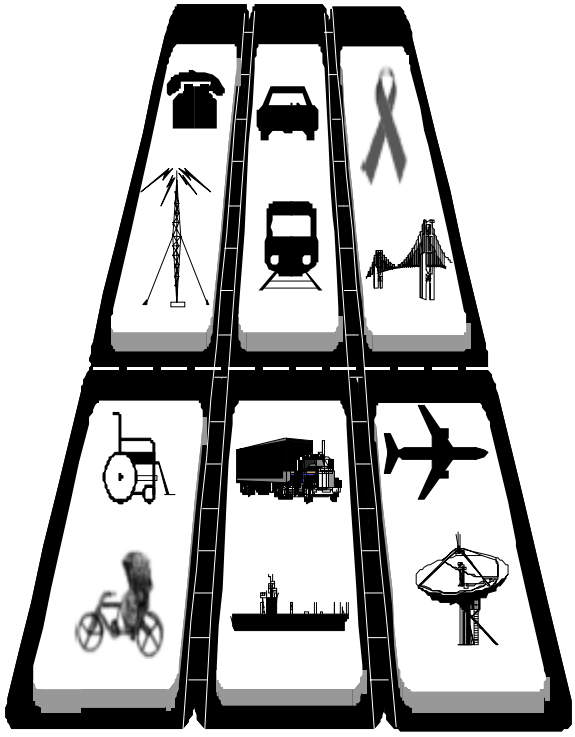


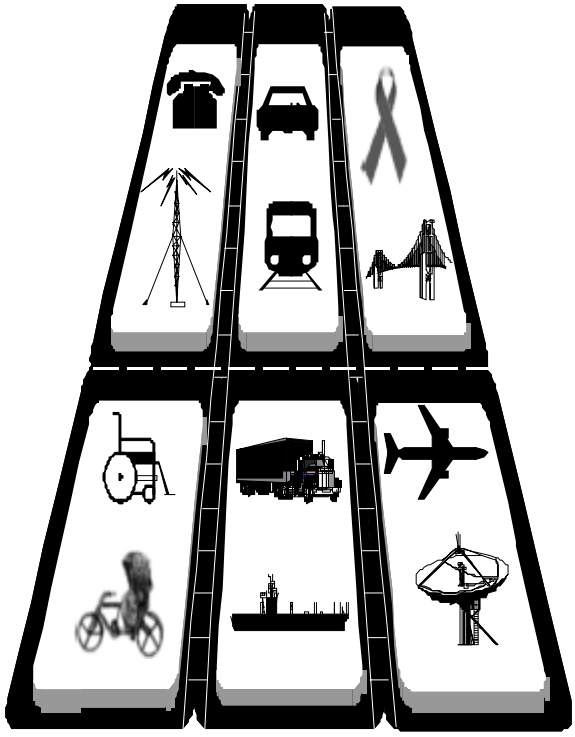
TRANSPORT AND COMMUNICATIONS BULLETIN FOR ASIA AND THE PACIFIC

No. 70

Logistics for the Efficient Transportation of Domestic Goods

UNITED NATIONS

ECONOMIC AND SOCIAL COMMISSION FOR ASIA AND THE PACIFIC



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Editorial Statement

The *Transport and Communications Bulletin for Asia and the Pacific* is a journal published once a year by the Transport, Communications, Tourism and Infrastructure Development Division (TCTIDD) of the Economic and Social Commission for Asia and the Pacific (ESCAP). The main objectives of the *Bulletin* are to provide a medium for the sharing of knowledge, experience, ideas, policy options, and information on the development of transport infrastructure and services in the Asian and Pacific region; to stimulate policy-oriented research; and to increase awareness of transport policy issues and responses. It is hoped that the *Bulletin* will help to widen and deepen debate on issues of interest and concern in the transport sector.

Each volume of the *Bulletin* focuses on a particular theme of interest, primarily in the transport sector. The themes for the last two issues of the *Bulletin* were urban transport and the participatory approach to transport infrastructure development. The theme chosen for this issue (No. 70) is logistics for the efficient transportation of domestic goods. Four articles which focus on some of the issues in domestic transport logistics and two good practices in the region have been selected. The first discusses some general issues in the logistics area and suggests actions to address them. The second discusses the possible gains in environmental improvement through reductions in emissions from the road transport sector at the macro level by improving efficiency in the logistics sector in Korea. The third and fourth are on good practices in logistics in Thailand, one in the rural area and one in the urban area. All the articles are policy oriented. It is expected that they will generate further debate on the issues that have been discussed and increase awareness of their policy implications and responses.

The *Bulletin* welcomes analytical articles on topics that are currently at the forefront of transport infrastructure development and services in the region and on policy analysis and best practices. Articles should be based on original research and should have analytical depth. Empirically based articles should emphasize policy implications emerging from the analysis. Book reviews are also welcome. See inside back cover for guidelines on contributing articles.

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TRANSPORT AND COMMUNICATIONS BULLETIN FOR ASIA AND THE PACIFIC NO. 70

CONTENTS

GOVERNMENTS AND INDUSTRY WORKING TOGETHER TO IMPLEMENT MODERN LOGISTICS

Des Powell*

ABSTRACT

Globally we have a marketplace built around continued economic growth, with trade between countries continuing to transcend national boundaries where barriers previously existed.

Globalization is a two-edged sword in that it provides opportunities to maximize comparative advantage, but it also intensifies competition. Therefore it is critical that Governments recognize the changes as they impact on areas that include investment, economic growth and infrastructure development.

Companies are using logistics as a key business tool to enable them to penetrate markets and improve returns. They are utilizing regional supply chains to challenge the status quo in terms of manufacturing locations, distribution channels, the number of suppliers and information systems. This has meant in many cases an evolution to intermodalism, a rationalization of suppliers in industry structure terms and an increase in outsourcing.

It is therefore important that Governments and industry work together to effectively manage the changes that will facilitate improved performance. These areas include the practical implementation of logistics, integrated infrastructure and policy development, the removal of impediments, information technology and communications, maximizing the benefits of foreign investment and managing the change.

I. BUSINESS TODAY

Any discussion about achieving improvement in logistics needs to be built on an understanding of what trends are driving business as a whole. Governments need to be aware of these trends so as to respond with appropriate policies. These trends should also guide Governments when considering how to work with industry to maximize the country's international competitiveness.

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The first of these is the changing marketplace at global, regional and local levels. Globally we have a marketplace built on continued economic growth, with trade between countries transcending national boundaries, where barriers previously existed. Multinational companies (MNCs) continue to grow through acquisitions and mergers as they build brands. Increasingly information technology (IT) and communications have become powerhouse sectors, not just in terms of business efficiency, but also in terms of being central to new business models.

Globalization is a two-edged sword in that it provides opportunities but also intensifies competition, therefore it is critical that Governments recognize these changes and interpret their likely impact when considering policy formulation. Companies operating globally are closely assessing each market's attractiveness when making strategic decisions regarding investment. In some cases, because of finite resources, this is leading to withdrawals from certain markets in order to focus on core growth regions.

Companies continue to strive to create customer value by a combination of differentiation and lowest cost as they pursue market growth and improved returns. As a consequence, logistics and supply chain management is increasing in importance as a means of delivering value in the international business arena. These market-driven dynamics have resulted in customers demanding more from logistics globally, which is impacting at a regional and local level.

Regionally we have observed the emergence of regional logistics planning, where cross-border transactions between subsidiaries of multinationals account for an increasing amount of international trade. This has facilitated the benefits of economies of scale from large production runs using high technology. This is resulting in some production sites becoming points of single or reduced product range. The outsourcing of logistics continues to grow strongly, with companies seeking to accelerate the uptake of modern logistics skills by standardizing processes and technology, developing formal account management relationships and managing single suppliers across regions. The regional approach aims to bring about market growth at lower cost and thereby deliver improved shareholder returns.

The Asian economic crisis of the late 1990s acted as a catalyst for companies seeking transformational change. Now that growth is returning to the region the possibilities of change will increase exponentially, challenging the status quo for many existing trading patterns, arrangements and relationships. Issues such as manufacturing locations, product range, distribution channels, the role of distributors, the number and quality of suppliers and the integrated systems technology are being continually re-evaluated.

At a local level these trends translate into continued industry reform and restructuring often at a pace quicker than in the past. The 1990s also saw social issues such as the environment, employment and social justice become increasingly relevant. Business is also requiring Governments to respond to economic and social trends through policy initiatives in respect to industry regulation, free trade, financial reform, taxation, social policies and infrastructure investment.

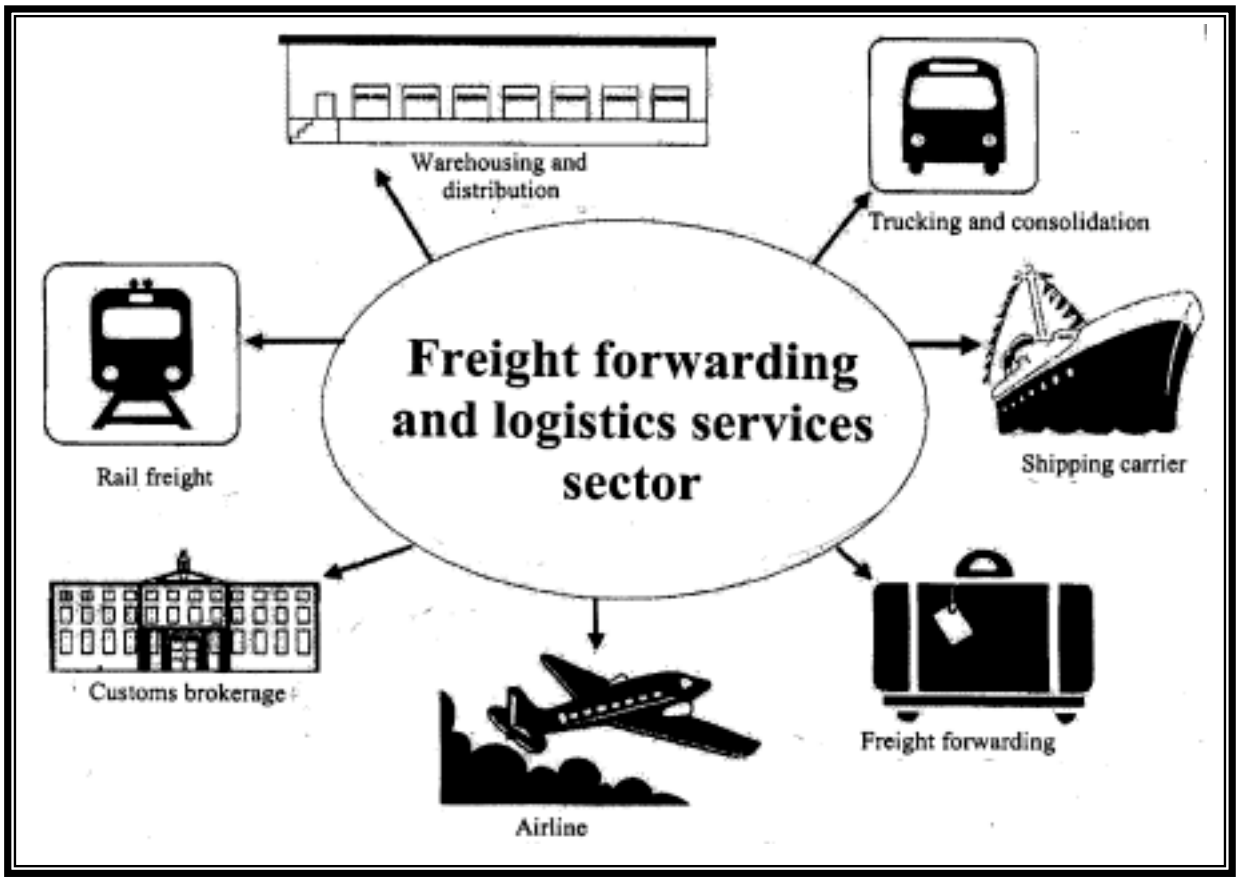
In dealing with these dynamics a major issue for Government and business is to effectively manage that change. The speed of business, the competitive environment and the deregulation of world trade require strong leadership at all levels. Those in senior roles often expect change to be automatically embraced, but such is not the case. Leadership often

determines the effectiveness of the strategies and tactics adopted by Governments and businesses. This is critical, yet change management is often given little thought or resource allocation. The issue is addressed in section V. F of this paper.

II. LOGISTICS TRENDS

Logistics is increasing its impact on business, as it creates value for companies and assists in delivering improved profits. The application of logistics varies across continents. Modern logistics is generally a new concept in Asia, with the focus on the basic transport processes of road, rail, air and sea. These processes have in some areas been integrated into what is known as multimodal transport.

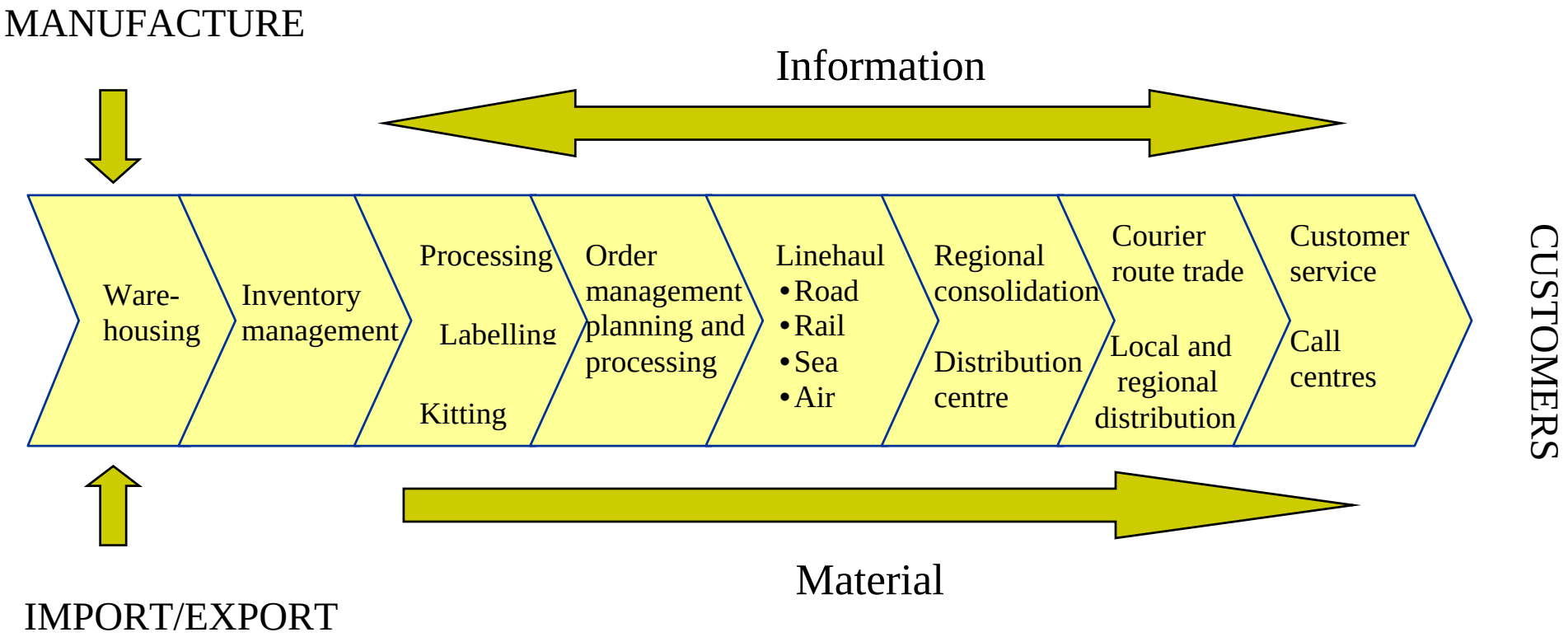
The following two figures demonstrate two views of logistics.Figure 1 outlines the functional approach that is generally adopted in Asia. The attributes of this approach focus on the individual operational aspects of transportation, where operational excellence is the dominant capability.



Source: Hong Kong Trade Development Council. China's freight forwarding and logistics: The path after entry to WTO, Research Report, July 2000.

Figure 1. An Asian view of logistics

Figure 2 reflects a contemporary Western view of logistics. This model focuses on the customer's perspective, from the point of supply through to the end user. The objective is to deliver superior value at the lowest cost. The competencies required depend upon building strong customer partnerships, client-specific solutions, and innovation and supply-chain systems integration. This model clearly takes a holistic approach and is the trend in modern economies.



Prior to assessing how logistics in Asia could move from its current stage of development, it is appropriate to consider how logistics has developed recently in some other regions.

A. Europe

The development of a single pan-European market remains the major influencing factor. This is placing pressure on traditional domestic logistics players to decide whether they can be a pan-European operator or carve out a product or service niche on a local level. This has led to industry consolidation, with smaller-sized operators being acquired by regional and global operators to fill a capability gap or geographical sector.

A major influence has been increasing competition as the prospect of postal liberalization in Europe (planned for 2003) has activated expansion from domestic monopolies to international service providers pursuing major growth. This is again in response to customer demands for increased geographical reach, a greater level of service capabilities and technology that integrates with their systems.

E-commerce although still in its infancy, is expected to generate growth; Scandinavian countries are leading the way with more Internet users per capita than the United States of America. This environment has led to those companies wishing to survive having to re-invent themselves from pure trucking (that is, asset-based) into IT-intensive logistics (that is, service-based) providers. This transformation has been rewarded by improved profits and increasing value on the share market.

B. North America

The growth in logistics as a specialist activity has been based on a strong presence of third-party providers (3PLs) that is, specialist logistics providers). 3PLs have been able to integrate warehousing and transportation activities. They were able to do so by using systems, initiatives such as dynamic route planning. This offered considerable benefits to customers in terms of providing seamless service and managing inventory. This integration has now developed to the point that multi-client networks can be sustained.

In the context of providing an integrated process, the management of information has become as important as the management of the operating processes, as suppliers seek to reduce inventory and provide flexibility in supply to customers. This creates value for their customers through cost reduction and facilitates increased market penetration.

This has required the development of customer-specific solutions based on a deep understanding of customer behaviour from the point of supply right through to the end user. Consequently, predicting and managing customer behaviour, together with providing integrated technology solutions, are capabilities that are differentiating logistics suppliers.

C. Australia

Companies continue to use outsourcing (growing at 10 per cent per year) as a means of enabling logistics to create value. This has led to a rationalization of suppliers as customers aim to standardize and initiate actions to more effectively manage suppliers. Customers continue to require innovation and demand low cost and this requires traditionally based transport companies to move from an operational focus to demonstrating how they can add value through the total logistics process. This has involved major investment to develop innovative equipment and an upgrading of technology. Providers are also challenged to respond to customers' requirements to manage inventory as a key means of reducing cost within their business.

Many Australian companies have moved their manufacturing offshore and, given its position as a net importer, Australia is often at the end of a supply chain. In terms of logistics, Australia is mature and Asia immature, yet Australia depends on Asia in a trade and supply-chain sense.

This is resulting in competition intensifying from 3PLs and international forwarders who have built relationships at a global and regional level and whose customers require a presence in Australia. International postal companies from the Netherlands and Germany have acquired logistics operations and major shipping companies continue to invest so as to vertically integrate from shipping into broader logistics solutions. This environment and the withdrawal from some sectors by traditional major players have resulted in a re-ordering of the Australian market.

D. Asia

The double-digit growth of the 1980s and early 1990s slowed owing to the Asian financial crisis that occurred in 1997. However, growth is returning and logistics is again high on the agenda as companies pursue market penetration and cost reduction. The introduction of modern logistics techniques to Asia has generally been done by those MNCs manufacturing or retailing, or both, fast-moving consumer goods. These companies have utilized modern logistics techniques to deal with the high levels of growth and a more demanding customer base. However, issues such as appropriate management, adequate technology and critical mass to justify the economics of central distribution centres have an important influence on the speed of logistics development. While the crisis has slowed the momentum of the mid 1990s, logistics is now emerging as a key tool in creating value.

This is occurring as global companies pursue regional solutions from a manufacturing and supply-chain perspective. This has led to decisions in respect to restructuring of manufacturing locations and redefining what products are sourced from what countries. They also are reviewing their historic distribution channels as the role of trading companies as distributors are being reassessed. Distributors have generally acted in both the sale and physical distribution functions, but some MNCs now believe it is strategically important to manage sales directly and to utilize specialist logistics firms for distribution.

This issue is often impacted on by government legislation in respect to foreign investment. The aftermath of the Asian financial crisis has resulted in a new wave of foreign investment as the majority of countries have freed up their foreign investment policy. As an example, in Thailand the freeing-up allowed Mayne Nickless, an Australian 3PL, to negotiate a majority foreign-owned joint venture. This was essential to meet customer expectations and to enable the board of directors of the company to have the confidence that adequate returns could be achieved in a country that they were entering for the first time.

These regional snapshots indicate five significant observations relating to the impact of logistics in Asia:

(a) Regional logistics strategies do play an important role in companies achieving their profit targets through market growth and the lowering of total cost;

(b) Companies have used the outsourcing of the logistics functions to 3PLs as a means of accelerating the take-up of modern logistics techniques;

(c) Industry rationalization has occurred in most countries, both from a customer and logistics-supplier perspective;

(d) The new concepts of logistics as they apply to modern economies demand an improvement of skills in management, information and other key capability areas;

(e) Governments can influence logistics development.

It is these observations that are discussed later in this article.

III. THE IMPORTANCE OF LOGISTICS TO GOVERNMENT

There is also evidence that, while the provision of integrated logistics is generally a new concept in Asia, Governments have been focusing on improving the management and efficiency of the transport sector.

Governments are now recognizing its value to domestic companies in improving their profit performance. It is recognized that in utilizing logistics to create value, domestic firms will also improve their international competitiveness. This is critical to underpinning a country's planned future economic growth. One example of this increasing importance is China, where a China Daily article of 6 June 2000 reported a government official as stating that China's logistics industry had not kept pace with the country's rapid economic development and the shift to a market economy. The article stressed the importance of a rapid development of the logistics industry to improve the quality and structure of the national economy. It put forward the view that the development of the logistics industry was necessary to meet the expected demands of growth in international trade expected from China's proposed entry to the World Trade Organization (WTO).

There is also recognition of the emergence of e-commerce, which is expected to expedite the growth of modern logistics. One cannot pick up a logistics magazine

or look at a conference agenda without seeing it in a pre-eminent position. Other technology initiatives such as the Global Positioning System and intelligent transport technology for toll collection, electronic data interchange, and for monitoring and charging are other rapidly developing areas of interest to Governments.

These issues indicate that the potential value of logistics as a value-creating business tool is understood at a government level. This reinforces the importance of moving to the contemporary Western model referred to in figure 2.

IV. A SELF-TEST FOR GOVERNMENTS

Governments, upon recognizing the importance of logistics, need to ensure that they conduct a frank assessment of their own situation. Such an assessment must take into account links to the marketplace (globally, regionally and locally) and industry generally.

To assist this, listed below is a range of questions that could be used in order to facilitate discussion that can assist in establishing the current situation. They are not meant to cover all the issues but are provided as a stimulus for discussion between Government and industry as a starting point for development an integrated plan.

- Do Governments understand the dynamics of today's marketplace?
- Is there adequate practical and commercial knowledge in the bureaucracy?
- Are there a significant number of industry leaders?
- How developed is the concept of modern logistics in the industry?
- Is there an integrated reform agenda with targets and measures that support a common vision?
- Is the investment in infrastructure adequate to support growth and reforms?
- Is infrastructure investment based on appropriate economic considerations?
- Are safety and environmental considerations adequate in logistics planning?
- Is the regulatory environment stimulating the desired outcome?
- Is industry taking the lead in self-regulation and setting industry standards?
- Is funding delivering practical outcomes?
- Do modes complement the shared vision rather than simply compete?
- Are taxes and charges being used to stimulate efficiency?
- Are efficiency targets in place for government departments?
- Is there an adequate consultation process with industry?
- Do best practice projects exist in conjunction with industry?
- Do economic development strategies adequately consider logistics issues?
- Do foreign investment regulations adequately support logistics development?
- Does appropriate education exist across the logistics industry?

- Does technology coordination exist?

V. POSSIBLE INSIGHTS TO ASSIST LOGISTICS DEVELOPMENT IN ASIAN COUNTRIES

Although the challenges for Asian countries are considerable, they are achievable. Multiple initiatives need to be put in place concurrently. Integrating an agreed action plan becomes a key role for Government. I would like to comment on a number of key areas and offer some observations that may assist those considering how to move forward. They include:

(a) The practical implementation of the concept of logistics;
(b) Integrated infrastructure policy and development;
(c) Removing impediments to logistics;
(d) Information technology and communications;
(e) Maximizing the benefits of foreign investment;
(f) The ability to manage change.

A. The practical implementation of the concept of logistics

The provision of modern logistics is a new concept in many parts of Asia. The transport sector is often viewed as a set of individual industries such as trucking, warehousing and freight forwarding, rather than as an integrated system which manages products and processes through the manufacturing and distribution process. The business objective of logistics is to support growth in profits and market share.

The shift in business thinking is being driven by customers who now assess logistics from the perspective of product flowing from the point of supply through to the customers. While evolution will support such a shift over time, customers and shareholders are demanding accelerated change. To that end I would advocate the consideration of initiatives such as attracting foreign investment that introduce logistics skills and educating the workforce on logistics:

(a) *Attracting foreign investment that introduces logistics skills*

The introduction of logistics to help local companies achieve increased international trade and profits can be accelerated by the specific targeting of foreign investment that brings with it modern logistics know-how. This would include the application of technology (warehouse management systems), the use of modern materials-handling equipment, the restructuring of traditional sales and physical distribution methods and skilled expatriates who could assist in the education of the local workforce. Such foreign investor firms are also likely to have relationships with freight forwarders and logistics providers, or both, that have the global and regional reach necessary to support export market expansion.

Given the trends in globalization it is also appropriate to consider MNCs which, through deregulation in either specific industry areas or in areas such as retailing and distribution, can now access critical mass in respect to the number of sites. This will support the viability of central and regional distribution centres and

provides the underpinning volume for an effective distribution network. This will be a key initiative in logistics development.

The targeting of foreign investment with logistics skills will accelerate the implementation of logistics practices. The business culture of these firms is also likely to be of significant benefit in driving growth. The targeting will be critical, as the matching of the logistics skills with the correct market opportunity will be important to ensure the viability of those enterprises. This is critical, as already in Asia there is significant foreign investment by a range of companies and issues such as joint venture suitability, access to the market, lack of scale and demand for short-term returns may currently be limiting the benefit of that investment. Governments may therefore give consideration to a strategic review with target foreign companies, including existing investors, aimed at packaging proposals to support the area of growth that is being targeted.

Another aspect that could be considered is the attracting of 3PL operators to the country. 3PLs have the capacity to upgrade skills in both the domestic and export markets.

A report in the McKinsey Quarterly estimated the 3PL market would grow 5 to 10 times faster over the next decade than the traditional freight forwarding market. In fact, evidence suggests that many large global players are migrating from a transport and freight forwarding focus by establishing specialist 3PL divisions within their organizations.

3PLs attempt to differentiate themselves from traditional transport companies by including engineers, business consulting, materials' handling, industry-specific skills, change management, business modelling, IT and management accounting. Such a multi-skilled resourcing approach enables them to have the necessary business perspective to be part of their customers' solution to the problem of delivering improved market performance.

Matching of domestic companies in growth industries with foreign companies from 3PLs and freight forwarding markets can accelerate the change to modern logistics thinking. It also has the benefits of increasing employment and providing the workforce with skills in critical capabilities. Our own experience in Thailand and Malaysia has been that numbers of employees grow, the skills of operational workforce are improved using technology implementation and middle management capabilities are developed. These are significant benefits.

(b) *Education in logistics*

The education and skilling of the workforce is critical to building capability. Five opportunities exist to educate different segments as to the role of logistics, its application and development.

(i) *Tertiary alliances*

A number of international tertiary institutions have, during the 1990s developed specific logistics programmes with strong reputations. Establishing

alliances with those institutions could result in programmes that introduce recent graduates to the country and could also include delivery of these programmes in Asian countries. There are a number of well-known institutions in the United Kingdom of Great Britain and Northern Ireland, North America and Australia that could be of value in establishing an appropriate alliance.

(ii) *Operational training*

A number of countries also conduct a range of programmes that provide specific industry skills training, commencing at industry entry level. Governments should consider the development of an alliance with a suitable institution for skills training in areas including warehousing, materials handling equipment and transport management. Such providers are often accredited through industry training bodies and alliances to enable transfer of training materials should be considered.

(iii) *Exchanges*

Governments could give consideration to fostering exchanges between local companies and overseas firms who have reputations for logistics skills in the targeted industries. These exchanges could also be at government level, which could introduce government officials to business trends in other countries that deal with policy formulation in respect to transport and logistics. This may be very valuable in helping to integrate government departments and manage change.

(iv) *Projects*

Governments may wish to consider developing skills through specific projects. This could involve specialist resources being brought in initially to guide project planning and then via the Internet, videos and communication to provide ongoing mentoring. Such projects could seek support from 3PLs and freight forwarders who may be prepared to commit resources in order to develop the country's knowledge of logistics. Encouraging business to make a commitment to the development of the industry is important.

Another approach to project education could be the use of expert skills to guide the demonstration of best practice approaches to logistics. The Government, working together with business, could nominate a target industry and support the development of a specific best-practice logistics project. This could fund the expert skills on for example a 6- to 12-month basis and then the project would be used to demonstrate initiatives to the wider business community. Government could also include support to such projects in terms of incentives or other resources.

A best-practice programme has been used in Australia by the Government to introduce new management techniques. Initially starting in the manufacturing sector, it spread into the retail and services sectors. A further example is the "supermarket-to-Asia" project facilitated by the Australian

Federal Government, which has worked in partnership with Australian industry to develop a business plan for Australian exports, with a major emphasis on the role of logistics. This particular project approach is well structured on the federal level, with a supporting structure of State air- and sea-freight councils. It has the added advantage of involving business commitment and is a practical example of industry learning in a practical sense. Again such projects have significant demonstration value and as a consequence the Australian Federal Government has recently announced a considerable increase in funding for appropriate project-based logistics development. It also has announced the development of an action agenda for the freight transport logistics industry.

(v) *General education among industry*

Another important issue is the development of knowledge among domestic firms in respect to the benefits of logistics. If Governments wish this to change, an active education programme among those sectors where growth is expected is essential. One example was a white goods manufacturer operating in Asia with a US$ 2 billion annual turnover and growing at 30 per cent per annum. It had five product streams and five separate approaches to logistics and distribution, five warehouses, five sets of sales strategies, five approaches to sets of purchasing negotiations and five sets of inventory management. This kind of duplication and lack of integration is a significant disadvantage in the marketplace and is likely to reduce the company's international competitiveness.

In this example, centralized coordination of logistics would result in improved asset utilization, less warehouse space, improved purchasing power and, in all probability, streamlined delivery patterns. These would all be critical elements in supporting export growth targets. Enterprises such as this need to be educated as to the benefits of adopting modern logistics practices. Governments have a role in facilitating this.

B. Integrated infrastructure policy and development

It appears that Governments generally acknowledge that infrastructure plays an important role in underpinning the ability to cope with projected growth. It therefore must be a priority to integrate infrastructure development so as to maximize the benefits of investment.

Observations show that the separation of ministries, unspecified funding allocations and a lack of formal transport planning can all minimize the impact of infrastructure investment. The reality of the private sector now funding infrastructure development adds another complication that needs to be appropriately managed.

Consideration needs to be given by Governments to the establishment of transport planning task forces that can sit above functional department structures (often multiple) and aside from the vested interests of individual enterprises in order to assess projects on the basis of regional and national importance.

Governments should endeavour to develop infrastructure plans based on economic considerations and consider all modes from a complementary point of view. They should also consider other initiatives such as inland container depots and transport interchanges, as well as streamlining processes and regulations for the integration of cargo across all modes. The standardizing of documents and consistent regulations relating to items such as dangerous goods can make it easier for businesses to operate.

A key initiative could be the establishment of a reform platform for regulations that impede logistics. This would require government departments to consult with shippers, transport operators, freight forwarders and their associations, as well as liaise across other government departments to ensure that barriers are removed.

Again, Australia offers some examples of industry input. A recent initiative was the establishment of freight action advisory groups. Governments should consider forming an advisory or reference group of industry and users who can come together on a regular basis to advise government agencies on trends and impediments. Governments and industry working together can offer significant benefits to all parties.

C. Removing impediments to logistics

A key issue identified earlier in the paper was the separation of departments, the role of provincial and local regulations and the split between the management of internal and external trade. These present a range of impediments to implementing integrated logistics and impact on international competitiveness.

This issue is not unique to Asian countries. Only in recent years has Australia initiated a national programme with the support of State Governments to standardize national road regulations in order to facilitate improved efficiency and competitiveness. The National Road Transport Commission has been the vehicle for reform and over the last few years has worked with industry and State Governments to develop reform agendas that have made considerable progress.

This process has in fact resulted in industry having to take on greater responsibility. The result has been that industry, via the Australian Trucking Association, has developed an effective National Peak Lobbying body that is now the bridge between Government and industry. This has led to industry-driven initiatives in truck safety, driver heath, fatigue management, technical coordination, codes of conduct and tax reform. A critical element in sustaining this level of industry involvement relates to delivering outputs of demonstrable value to the industry, funding links between Government and industry, and delivering benefits to those sections of industry that lift standards. The air- and sea-freight councils mentioned above are also active in developing reform agenda in respect to barriers to development.

There are a number of examples across Asia where processes and systems are not consistent across departments. A recent example relates to lack of consistency in customs processes and driver and truck records in a country. As a result, the

maximum asset utilization possible from a truck fleet was 45 per cent. The development of a consistent process in such a situation would be an ideal opportunity for a project between Government and industry.

In that case, the inability of the operator to service customers was limited by the non-availability of trucks (when they were sitting idle) with a resultant reduction in service levels. Such reductions in service levels cause delays in the supply chain of up to 25 per cent and uncertainty of supply times for customers. In addition, higher prices may have to be changed for transport services to achieve a suitable return on the investment made.

Ultimately time delays, the higher costs of doing business and uncertainty caused by these types of procedural issues can cause current and potential investors to review their investment decisions and lead them to consider investing in other regions or countries.

Reform in these areas should be a priority for Governments, as industry has expectations that protocols will be improved. Action task forces that include industry participation should be considered as a means of removing such barriers and driving efficiency to support country's expected trade growth.

It would also be expected that a reduction in the impediments would not result in any major employment issue, as economic growth and the redeployment of staff to other key areas requiring efficiency improvement would result in an overall benefit.

D. Information technology and communications

IT and communications have been identified as crucial to the development of modern logistics; in some countries the poor reliability and high cost of IT services is hampering that development.

I heard of a case recently where a 3PL was operating an MNC warehouse and had planned to connect a warehouse management system at multiple sites so as to enable all sites to accurately advise of warehouse capacity, location of stock, inventory on hand, and so forth. Currently the lack of reliable IT connections across multiple sites means enquiries from customers and staff cannot be answered speedily and therefore time and resources are wasted.

The experience of that company was that the reliability of existing lines was so poor that improvements were prohibitively expensive. They stated that the high cost of installing lines and local calls is a barrier. They also stated that the lack of reliability remains a major issue as lines are used for computer transfer of data and that it was not uncommon for 56 Kb/s modems to be working at only between 2 and 10 per cent of capability.

This is not the quality of infrastructure on which to base an industry for which the effective and efficient transfer of information is critical. Its improvement must become a priority from both a service and a cost point of view. It will be absolutely essential in order to have the capability to take up e-commerce. While it is recognized that e-commerce will have a major impact on logistics, I have not chosen to discuss it

in detail in this article as the focus here is on the basics which must be in place to support such developments as e-commerce.

E. Maximizing the benefits of foreign investment

The insight I would wish to offer does not relate to the specific strategies or the merits of policy proposals under consideration by Governments, but rather to the issue of support services. While the general direction of foreign investment policy can be clear, implementation of the changes requires a major shift in the practices, skills and culture of agencies and departments dealing with foreign enterprises. Governments need to ensure that training and education on these changes are comprehensive and that there is a change in culture from what is often a single departmental mentality to one that has as its prime goal the encouragement and support of business. Making it easy to do business should become a major theme.

Any freeing-up of foreign investment would bring with it major pressures on standardizing procedures and rules so as to ensure consistent implementation. This would need to include a significant education element for both local and foreign entities. It is also important that Governments acknowledge that freeing-up would require consideration of a shift from a strict enforcement of institutional requirements to one where industry introduces self-regulation via accreditation programmes and other initiatives such as codes of conduct among industry participants. This would be very relevant to the transport and freight-forwarding sector. The establishment of industry-driven initiatives in this area, based on international standards, would make business easier and allow the focus of enforcement on those who do not comply.

Speed in dealing with industry would also be an issue. Currently dealings with Government departments in some countries are considered slow by industry. Governments may wish to consider re-engineering key business services to a best-practice model so as to set a standard that would encourage investment. The setting of benchmarks can be a valuable tool in raising standards.

Governments should give consideration to encouraging service providers in industries associated with logistics to develop industry associations that can assist Governments in coordinating with industry. This would help with the establishment of standards consistent with international standards (in terms of documents, service and so forth) that should be supported by government legislation in respect to sanctions and penalties.

A particular emphasis could be in the area of advice in respect to joint ventures. Governments may wish to consider how it may promote “best practice” in order to develop effective joint ventures. It would be our belief that increased foreign investment may be followed by a high level of frustration between joint venture partners. It is my observation that in Asia joint ventures can be valuable in creating a successful business. Foreign and local partners often have different expectations about how things should be done. Therefore, the time taken to obtain a correct match in skills, strategic intent and culture may often be a long one. The issues of management control, dividend policy, veto rights, pre-emptive rights, management decision-making, the use of expatriates, ongoing research and development are often glossed over. The Western tendency is to rush, often without time for the development of

proper relationship and trust. Like many aspects of business the success of a joint venture depends on trust and stability. Initiatives Governments could take in this regard would assist in maximizing the benefits of foreign investment.

F. The ability to manage change

In considering in broad terms the desired role of logistics in supporting economic development, it is important to be realistic as to what can be achieved and in what timeframe. The consequence, however, of the rapidly changing global and regional environment is that it will be critical for Governments to work concurrently at a range of levels within both Government and business.

As stated at the outset of this paper, for Governments to achieve the objective of change, management must receive the appropriate level of attention. The global and regional environment would continue to change. The ability to manage this change will be as much about culture and leadership as it is about strategies and tactics. Establishing a shared vision at both government and business levels will be critical. While the pressure for change as a result of globalization might be clear to the Government, unless that change is communicated and understood at all levels its intended benefits might not be achieved. A clear plan involving key industry sectors and leaders may be an essential step in demonstrating leadership in areas such as logistics.

At a personal level, individuals do not act unless they feel a pressure for change. This often only occurs as the result of a major crisis that impacts on them from a financial or job security viewpoint. Until individuals decide to act differently as a result of the changes around them, little may change. An imperative for change has to exist and those implementing that change should ensure that any plans go to all levels of government and business. Governments must ensure that they adequately align their business community and workforce with any new directions they adopt.

The skilling of management and workforce will also be important in developing the competencies and capabilities required. Strong leadership by management at all levels is critical so that those at an operational level in either business or Government see the commitment to change coming from the top. Communication and the involvement of staff and customers are often critical to getting the necessary buy-in for change.

CONCLUSION

Logistics does have the capacity to be of significant value to both Governments and industry. It is an essential tool for companies to achieve increased market penetration and improved returns. Logistics suppliers that innovate, integrate and work with their customers are making significant progress.

The challenge is for Governments and industry to work together to educate companies in the use of modern logistics skills, encourage the transformation of traditional transportation operations into logistics providers, develop infrastructure (including IT) and manage the change.

IMPROVING EFFICIENCY IN THE LOGISTICS SECTOR FOR SUSTAINABLE TRANSPORT DEVELOPMENT IN THE REPUBLIC OF KOREA

Sungwon Lee*

ABSTRACT

Freight transportation has increased very rapidly in the Republic of Korea owing to economic growth and expanding international trade. However, the freight transport sector in the Republic of Korea has been regarded as inefficient and the inefficiencies can be attributed to many factors, including an outdated regulatory framework, business practices and a lack of proper infrastructure. Since freight transport demand is derived from economic activities that are expected to grow in the future, improving efficiency in the sector has important implications for sustainable transport development in the country.

In the present paper, the past trends and characteristics of domestic freight transportation in Korea are examined. The modal shares of domestic freight transport are analysed and future freight volumes by different modes are estimated, based on current trends and an alternative scenario in consideration of the proposals for future investment in transport infrastructure development. The effects in terms of greenhouse gas emissions for these two alternative future freight transport conditions are examined. The causes of inefficiency in the freight transport sector in the Republic of Korea, which includes infrastructure capacity problems, regulatory framework and business practices, are also discussed.

The previous and ongoing efforts to improve efficiency in the logistics sector through policy measures are discussed. The policy measures focus mainly on a modal shift to environment-friendly modes, infrastructure provision and enhancing operational efficiency. Finally, an estimate of the potential reduction in CO_2 emissions as a result of these efforts is presented.

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INTRODUCTION

Freight transportation has increased very rapidly in the Republic of Korea owing to fast economic growth and expanding international trade. It has provided indispensable service to economic growth. However, it has also been regarded as relatively inefficient. The inefficiencies can be attributed to many factors, including an outdated regulatory framework, business practices and a lack of proper infrastructure. Since freight transport demand is derived from economic activities that are expected to grow in the future as well, improving efficiency in the freight transport sector has important implications for sustainable transport development in general.

In the present paper, the past trends and characteristics of domestic freight transportation in the Republic of Korea are examined. The modal shares of domestic freight transport are analysed and future freight volumes by different modes are estimated, based on current trends and an alternative scenario in consideration of the proposals for future investment in transport infrastructure development. The causes of inefficiency in the sector are then discussed, including regulatory regimes, business practices, the lack of standardization in logistics facilities and equipment and the lack of an integrated logistics information system. Finally, past and present policy measures to improve efficiency in the logistics sector in the Republic of Korea and the potential impact of these efforts on energy consumption and the environment, particularly in terms of a reduction in greenhouse gas emissions are examined.

I. CHARACTERISTICS OF FREIGHT TRANSPORT IN KOREA

During the eleven-year period between 1988 and 1999, the growth in domestic freight movement showed a high positive correlation with the growth of real gross domestic product (GDP). Up to 1997, freight transportation increased very rapidly along with the increase in GDP levels. However, the domestic freight transport volume dropped dramatically in 1998 owing to the economic crisis and has not yet recovered its previous level. Table 1 shows real GDP and domestic freight movement in the Republic of Korea by year.

Table 1. Change in real GDP and domestic freight in the Republic of Korea, 1988-1999

Year	Real GDP (billions of won)	Annual change in real GDP (percentage)	Domestic freight (millions of ton-km)	Annual change in domestic freight (percentage)
1988	226,543.2	-	59,047	-
1989	241,006.9	6.38	61,522	4.19
1990	263,430.4	9.30	65,704	6.80
1991	287,737.9	9.23	74,091	12.76
1992	303,383.9	5.44	90,268	21.83
1993	320,044.2	5.49	96,438	6.84
1994	346,448.1	8.25	97,782	1.39
1995	377,349.8	8.92	110,722	13.23
1996	402,821.2	6.75	114,367	3.29
1997	423,006.7	5.01	121,899	6.59
1998	398,312.6	-5.84	87,316	-28.37
1999	436,798.5	9.66	86,525	- 0.91

Source: Lee, Sungwon, Myungnee Lee and others, 2001. Macroeconomic impact analysis of environmental regulations in the transport sector, internal document (Korea Transport Institute).

Freight transportation in the Republic of Korea has several distinctive characteristics. The most salient trend in the domestic freight transport in the Republic of Korea is the ever-growing role of road transport, both in terms of absolute tonnage transported and its modal share. The dominance of road freight transport has been led by the explosive increase in private truck operations in domestic freight movement. Contrary to the dominance of road freight transport, the role of rail transport, which is considered as more environment-friendly, has shrunk, both in terms of tonnage transported and its modal share. The reduced role of rail is owing partly to capacity constraints, as more time slots have been assigned for passenger services while the total rail capacity has remained virtually the same. Another important environment-friendly mode, maritime transport, has been able to maintain its relatively stable modal share in freight transportation in recent years. Freight transportation by air has increased in absolute terms, but its modal share is still negligible in the domestic sector. Table 2 shows the trend of freight modal share during the last 11 years.

Table 2. Modal share of domestic freight movement in the Republic of Korea, 1988-1999

(Millions of ton-km and percentage)

Year	Road	Rail	Maritime	Air	Total
1988	28,603 (48.44)	13,784 (23.34)	16,617 (28.14)	43 (0.07)	59,047 (100.00)
1989	30,002 (48.77)	13,605 (22.11)	17,852 (29.02)	63 (0.10)	61,522 (100.00)
1990	30,842 (46.94)	13,663 (20.79)	21,127 (32.15)	72 (0.11)	65,704 (100.00)
1991	34,781 (46.94)	14,494 (19.56)	24,737 (33.39)	79 (0.11)	74,091 (100.00)
1992	39,910 (44.21)	14,256 (15.79)	36,008 (39.89)	94 (0.10)	90,268 (100.00)
1993	43,210 (44.81)	14,658 (15.20)	38,465 (39.89)	105 (0.11)	96,438 (100.00)
1994	48,661 (49.76)	14,070 (14.39)	34,935 (35.73)	116 (0.12)	97,782 (100.00)
1995	52,825 (47.71)	13,838 (12.50)	43,936 (39.68)	123 (0.11)	110,722 (100.00)
1996	54,834 (47.95)	12,947 (11.32)	46,452 (40.62)	134 (0.12)	114,367 (100.00)
1997	63,741 (52.29)	12,710 (10.43)	45,299 (37.16)	149 (0.12)	121,899 (100.00)
1998	43,343 (49.64)	10,372 (11.88)	33,461 (38.32)	140 (0.16)	87,316 (100.00)
1999	42,603 (49.23)	10,072 (11.64)	33,699 (38.95)	151 (0.18)	86,525 (100.00)

Source: Lee, Sungwon, Myungnee Lee and others, 2001. Macroeconomic impact analysis of environmental regulations in the transport sector, internal document (Korea Transport Institute).

In road transport, only about one fifth of freight is moved by commercial carriers, which are regarded as more energy efficient owing to their higher load factor. Most of the remaining freight is transported by privately owned trucks which are less efficient and cause more damage to the environment. The prevalence of less efficient private freight transport is one of the major causes of energy inefficiency in the transport sector.

Until recently, the commercial freight industry in the Republic of Korea was protected by a strict licensing system. It also suffered from the collusive behaviour of the operators. As a result, the industry lost its competitiveness. Like other industries under entry regulations and price control, the domestic freight transport industry has suffered from low productivity and service levels. Nor has the industry been responsive to changing consumer needs. As a result, many consumers have turned away from commercial freight transporters and relied on their own private freight transportation, which has ultimately led to the dominance of private transporters.

In general, the logistics sector in the Republic of Korea can be regarded as relatively inefficient compared with the advanced countries. Logistics costs in the Republic of Korea are estimated at over 16 per cent of GDP as of 1995, which is at least 50 per cent more than those of the United States of America.[1] The major causes of inefficiency are the shortage of logistics-related infrastructure, operational problems and the problem of economies of scale in logistics firms, which are mainly small and medium-sized.

All the major freight-related infrastructure, that is, railways, highways, seaports and airports, is experiencing capacity problems. The capacity-related problems are causing congestion and creating bottlenecks along the major arteries of freight transportation. Rail freight transportation is a particular case in point. It has been severely squeezed to accommodate an increased number of passenger services, which has caused severe capacity constraints and consequent falls in market share and the volume of freight transported. Other logistics-related facilities such as freight terminals and storage facilities also have capacity constraints. Infrastructure capacity problems, which result in bottlenecks and congestion, are the main sources of high logistics costs. Besides increasing costs, they also have adverse implications for energy consumption and the environment.

From an operational perspective, there are also other sources of inefficiency in domestic freight transportation. The state of utilization of IT is one such important area. There are noticeable gaps in the utilization of IT among logistics service providers of different transportation modes. Electronic information systems have often been developed by IT firms in isolation from each other. As a result, data and information are not shared or cannot be exchanged. This deficiency in logistics information systems has led to unnecessary delays in freight transportation, overstocking of inventories, a low load factor and inefficient trucking operations, all of which have contributed to higher costs. Another very important problem that needs urgent attention is the lack of standardization in logistics-related facilities and equipment. Logistics can be regarded as a system that needs centralized operation and management. Standardizing logistics-related equipment and facilities could improve overall efficiency in freight transportation.

Last, the slow progress made in improving logistics information systems and standardizing logistic-related facilities and equipment has been largely attributed to the fact that most logistics firms in the Republic of Korea are small and medium-sized businesses. The lack of economies of scale and reliability problems associated with small logistics firms have often provided a strong incentive for manufacturing firms in the Republic of Korea to set up their own logistics division or even to operate their own freight vehicle fleets.

[1] Logistics costs are defined here as the sum of transportation and storage-related costs.

II. THE GROWTH OF ROAD FREIGHT TRANSPORT AND ITS IMPLICATIONS FOR SUSTAINABLE TRANSPORT DEVELOPMENT

Freight transport demand, by nature, is a derived demand that may be affected by various socio-economic factors and the level of economic activity. Forecasting of underlying variables representing these factors, therefore, should precede the forecasting of freight transport demand. Table 3 shows forecasting of key economic indicators that are considered relevant in estimating domestic freight transport demand. Among the economic indicators, the vehicle ownership rate has been estimated by a lagged power growth function, where vehicle ownership approaches a pre-assumed saturation point. The function had a stock adjustment term, considered real per capita GDP as a purchasing power proxy, and the vehicle ownership cost was represented by the sum of vehicle purchase cost and annual fuel cost (Lee and others 1999). For estimation purposes, real per capita GDP and fuel prices have been assumed to increase at 3 per cent per annum over the next 20-year period.

The vehicle ownership rate is estimated to increase from about one vehicle for every four persons in 2000 to about two vehicles for every five persons in 2020. The forecast vehicle ownership rates are presented in table 3 along with forecast population and number of registered vehicles.

Table 3. Key economic indicators, 2000-2020

	1995	2000	2005	2010	2015	2020
Population (Thousands of persons)	45,093	47,274	49,123	50,618	51,677	52,358
Per capita GDP (Thousands of won)	8,459.1	9,101.2	10,550.8	12,231.3	14179.4	16,437.9
Vehicle ownership rate (per person)	0.1878	0.2444	0.2862	0.3263	0.3643	0.3994
Vehicle registration (Thousands of vehicles)	8,469	11,555	14,061	16,516	18,828	20,909

Source: Lee, Sungwon, Meeyoung Shin and others,1999. Comprehensive policy measures for environment-friendly transport (Korea Transport Institute).

The total vehicle mileage for each vehicle type is estimated by using the forecast number of vehicles and the estimated average vehicle mileage. Average vehicle mileage has been estimated by fitting a growth curve that best explained the past trend. It may be noted here that the estimated average annual vehicle mileage decreases as the number of vehicles increases. Table 4 presents the estimated total vehicle mileage by vehicle type up to 2020. As shown in the table, the total truck mileage is expected to almost double in the 20-year period between 2000 and 2020. The predominance of private trucks in freight transportation is expected to continue during this period.

Table 4. Estimated vehicle mileage, 2000-2020

(Millions of km)

		1999	2000	2005	2010	2015	2020
Passenger car	Private passenger car	145,679	150,566	179,162	209,209	237,600	263,099
	Taxi	22,265	22,871	26,757	31,086	35,251	39,019
	SUV[a/]	7,601	7,856	9,348	10,915	12,397	13,727
Bus	Small and medium private	12,541	13,528	17,138	20,402	23,511	26,331
	Heavy-duty private	2,640	2,848	3,608	4,295	4,950	5,543
	Small and medium commercial	202	218	278	332	382	428
	Heavy-duty commercial	3,753	4,062	5,179	6,173	7,114	7,967
Truck	Small and medium private	41,881	45,254	57,542	68,557	79,011	88,489
	Heavy-duty private	2,435	2,631	3,345	3,986	4,594	5,145
	Small and medium commercial	3,154	3,413	4,352	5,187	5,978	6,695
	Heavy-duty commercial	6,308	6,827	8,705	10,374	11,956	13,391

[a/]SUV: sports utility vehicles such as four-wheel drive jeeps.

Greenhouse gas emissions have been estimated by vehicle type according to the revised Intergovernmental Panel on Climate Change guidelines and relevant emission factors of representative vehicle type (IPCC 1996). Table 5 presents the estimation results. In 2020, emissions by freight vehicles of CO_2, which is the most important greenhouse gas, are estimated to account for about 31 per cent of total emissions, compared with 38.7 per cent in 1999 (Lee, Lee and others 2001). Although the freight transport sector is not expected to grow as much as the transport sector as a whole, managing freight transport demand remains crucial to reducing overall energy consumption and the adverse environmental impacts caused by emissions from transport vehicles.

The forecast of freight transport modal shares up to 2020 is presented in table 6. The forecast is based on the assumption that the current trend will continue and new infrastructure will be constructed to satisfy the increase in demand. This forecast can therefore be considered as a baseline case against which the effects of policy measures can be analysed. Freight transport is expected to almost double during the next two decades if the current trend continues. The environmental burden imposed by freight transport will therefore be much greater in the future and therefore special efforts will be required to ensure sustainable transport development in the Republic of Korea.

Table 5. Estimation of greenhouse gas emissions, 2000-2020

(Thousands of tons)

	Year	NO_x	CH_4	NMVOC	CO	N_2O	CO_2
Passenger car	1999	119.5	4.0	100.0	535.3	0.1	28,885.0
	2000	126.8	4.3	106.4	570.8	6.3	30,991.0
	2005	156.9	5.4	133.8	723.3	8.4	40,526.7
	2010	189.3	6.6	164.1	894.3	11.0	51,638.3
	2015	220.8	7.7	191.4	1043.0	12.8	60,223.5
	2020	246.4	8.5	213.6	1164.2	14.3	67,218.4
Bus	1999	53.0	0.6	16.3	71.6	0.1	8,374.5
	2000	56.2	0.6	17.4	76.3	0.4	8,891.4
	2005	62.3	0.7	19.8	87.0	0.4	9,953.4
	2010	68.8	0.8	21.9	96.1	0.4	10,997.4
	2015	79.4	0.9	25.3	110.8	0.5	12,681.8
	2020	87.1	1.0	27.7	121.6	0.6	13,916.9
Truck	1999	154.3	2.6	30.3	132.7	0.1	23,534.4
	2000	162.1	2.8	31.8	139.4	1.3	24,717.2
	2005	169.8	2.9	33.4	146.5	1.4	25,921.6
	2010	187.6	3.2	36.9	161.9	1.5	28,640.5
	2015	216.4	3.7	42.6	186.7	1.7	33,027.0
	2020	237.4	4.0	46.7	204.9	1.9	36,243.7
Total	1999	326.8	7.2	146.6	739.7	0.3	60,794.0
	2000	345.1	7.7	155.7	786.6	7.9	64,599.6
	2005	389.0	9.0	187.0	956.8	10.2	76,401.7
	2010	445.8	10.6	222.9	1,152.3	13.0	91,276.1
	2015	516.5	12.3	259.2	1,340.5	15.1	105,932.3
	2020	571.0	13.6	288.1	1,490.6	16.8	117,379.1

CH_4: methane; CO: carbon monoxide; CO_2: carbon dioxide; N_2O: nitrous oxide; NMVOCs: non-methane volatile organic compounds; NO_x: oxides of nitrogen

Table 6. Baseline forecast of domestic freight transport in the Republic of Korea, 2000-2020*

(Millions of ton-km and percentage modal share)

Year	Road	Rail	Maritime	Air	Total
2000	43,883 (49.23)	10,375 (11.64)	34,712 (38.95)	156 (0.18)	89,126 (100.00)
2005	51,066 (49.23)	12,073 (11.64)	40,394 (38.95)	182 (0.18)	103,715 (100.00)
2010	59,791 (49.23)	14,136 (11.64)	47,295 (38.95)	213 (0.18)	121,435 (100.00)
2015	70,462 (49.23)	16,659 (11.64)	55,736 (38.95)	251 (0.18)	143,108 (100.00)
2020	83,597 (49.23)	19,764 (11.64)	66,125 (38.95)	298 (0.18)	169,784 (100.00)

* This forecast represents the baseline case under the assumption that current modal share will be maintained in the future.

III. POLICIES FOR IMPROVING EFFICIENCY IN FREIGHT TRANSPORT

Improving efficiency in freight transportation can be approached in various ways. The improvement of vehicle efficiency could be a major area of development. Possible measures include improving the aerodynamics of the vehicle design, increasing engine efficiency, or developing alternative fuel vehicles that are less polluting and more environment-friendly. Transport policy measures could also help to improve efficiency in freight transportation. Such measures could include policies in favour of a modal shift to more energy-efficient modes, investments in infrastructure expansion and regulatory reforms to promote efficiency and competitiveness in the freight transport industry. Although vehicle efficiency is important in securing environmental sustainability, the present paper focuses on policy-oriented measures in discussing the efforts of the Republic of Korea for sustainable transport development through improvements in the logistics sector.

The Government of the Republic of Korea recognizes the importance of logistics-related problems in the country and has enacted several pieces of legislation and made long-term plans to improve efficiency in the sector. In 1995, the Logistics Facilitation Act was revised and the Distribution Centre Development Act was passed in order to provide financial incentives to developers. In 1997, the Freight Industry Act was passed in order to ease the entry regulations governing entry into the industry. These pieces of legislation were intended to facilitate the development of logistics-related infrastructure and to deregulate the freight industry in order to increase the efficiency of the logistics sector and thereby strengthen the overall competitiveness of the Republic of Korea economy (Transport Yearbook 1998).

Energy efficiency in freight transportation can be achieved by a modal shift to a more energy-efficient means of transportation such as rail. In order to ease railway capacity constraints such as those mentioned earlier, 23 new railway lines with a total length of 3,870 km are being planned, among them the Seoul to Pusan High Speed Rail Link (Ministry of Construction and Transport 1999). It is expected that the expanded railway network would relieve capacity constraints and be able to reverse the current trend and increase the market share of rail in domestic freight transportation.

In order to remove bottlenecks along the major arteries of freight transportation, major investments in road transport infrastructure are also planned. By 2011, 33 new expressways are to be constructed, with a total length of 3,383 km. In the air transportation sector, three new airports and the expansion of nine major domestic airports are also planned. In the water transport sector, four new seaport developments and the expansion of seven

seaports are currently under way.

In the area of logistics-related infrastructure development, eight integrated freight terminals and four inland container depots are being constructed. These new facilities are expected to lower logistics costs, improve overall efficiency and contribute to regional development.

For logistics information system development, an integrated logistics information system is being developed in three stages. The integrated system is intended to enable electronic data interchange (EDI) and provide freight traffic information such as real-time freight and vehicle location. In the first stage of development (1996-1998) overall planning and construction of the main EDI centre were completed; in the second (1998–2000) commercial EDI service was planned and in the third stage (2001–2015) further development of commercial EDI service and development of several local EDI centres are planned.[2]

The Government and the private sector are also pursuing the standardization of logistics-related facilities and equipment. The Government has adopted the "unit load system rule" that provides standardized specifications for containers, loading equipment, freight trucks and freight packages. Tax exemption for investments in logistics standardization is also allowed, in order to enhance the standardization process.

Meanwhile, government regulations on the logistics industry have been relaxed. The complicated classification system in the freight transport industry has been repealed and regulations on entry to the industry via a system of licences have been replaced by a less stringent registration system which allows entry into the industry by firms meeting specified minimum requirements. Previously, entry into the freight transport industry required certain amount of minimum endowed capital as well as a minimum number of freight trucks and parking and other related facilities. Before 1999, the minimum capital requirement for the regular freight liners was 300 million won and the minimum fleet requirement was 30 trucks. Even when all of these requirements were met, the licensing of a new freight operator was a long and strict process.

Since freight modal shares can be influenced by infrastructure development and policy instruments, long-term freight modal shares have been estimated taking into account future infrastructure investments and changes in policy. Table 7 gives such a freight modal

[2] For further information on EDI in freight transportation in the Republic of Korea, refer to Kwon, O., 1997. "Proposed advanced commercial operations in the Republic of Korea", *Transportation Research Record 1602*, (Transportation Research Board, Washington, DC).

share estimation. Most investments planned in the logistics sector are geared to expanding the role of energy efficient transport modes such as railways and maritime transport. These investments are intended to shift a part of the road freight traffic to railways and water transport.

Table 7. Long-term forecast of domestic freight transportation in the Republic of Korea taking into account major investments in infrastructure development, 2000-2020

(Millions of ton-km and percentage modal share)

Year	Road	Rail	Maritime	Air	Total
2000	43,285 (48.57)	10,700 (12.01)	34,976 (39.25)	164 (0.19)	89,126 (100.00)
2005	46,860 (45.18)	14,483 (13.96)	42,126 (40.62)	245 (0.24)	103,715 (100.00)
2010	50,730 (41.77)	19,601 (16.14)	50,737 (41.78)	366 (0.31)	121,435 (100.00)
2015	54,921 (38.37)	26,529 (18.53)	61,109 (42.71)	548 (0.39)	143,108 (100.00)
2020	59,457 (35.02)	35,906 (21.15)	73,601 (43.35)	820 (0.49)	169,784 (100.00)

Note: The road freight forecasting has been done by the author. Rail and other modal shares have also been estimated by the author, taking into account infrastructure investments in "National logistics visions and policies for the twenty-first century" (Korea Transport Institute 1999).

In table 7, it can be seen that the share of rail freight transport is expected to grow rapidly. This is because the high speed rail link currently under construction would relieve some existing rail capacity from passenger transport to freight transport. Freight transport by air is also expected to grow rapidly, but the absolute tonnage transported is expected to remain small. The share of road freight transport is expected to decrease over the next 20 years as rail and maritime transport expand. Although losing market share, road freight transport would still experience significant growth in absolute terms owing to growth in overall freight movement demand.

The expected changes in freight modal shares will have a favourable impact on the environment: they are expected to increase energy efficiency and thereby help in reducing the greenhouse gas emissions produced by the transport sector. Estimates of CO_2 emissions from freight transportation have been made for this alternative scenario of modal shares and are presented in table 8. The estimation takes into account the current energy efficiency of different modes and forecast changes in modal share. The energy efficiency of different modes has been calculated and checked against the current energy consumption statistics for accuracy. Table 8 shows the potential greenhouse gas (CO_2) reductions up to 2020 owing to changes in freight modal shares. It is estimated that a reduction of CO_2 emissions of up to 6.54 per cent can be achieved in the transport sector by the proposed investments and the

consequent modal shift.

Table 8. CO_2 emissions by type of domestic freight transport and their reduction potential, 2000-2020

(Thousands of tonnes of carbon)

		2000	2005	2010	2015	2020
Baseline	Road (private)	5,409	6,294	7,370	8,685	10,304
	Road (commercial)	1,203	1,400	1,639	1,931	2,291
	Rail	74	86	101	119	141
	Maritime	347	404	473	557	661
	Air	63	73	86	101	120
	Total by freight transport	7,096	8,257	9,668	11,394	13,518
Modal shift policy as in "National logistics visions and policy for the twenty-first century" (Korea Transport Institute, 1999)	Road (private)	5,409	6,049	6,446	6,525	6,604
	Road (commercial)	1,203	1,318	2,222	2,847	3,541
	Rail	74	104	134	182	246
	Maritime	347	400	437	532	647
	Air	63	101	146	197	266
	Total by freight transport	7,096	7,973	9,387	10,282	11,304
Reduction potential		-	284	282	1,111	2,214
Total emissions by the transport sector		18,681	22056	26,565	30,855	33,869
Reduction rate (percentage)		-		1.06	3.60	6.54

Source: Lee, Sungwon, Myungmee Lee and others, 2001. Macroeconomic impact analysis of environment regulation in the transport sector, internal document (Korea Transport Institute).

CONCLUSION

Freight transportation is indispensable to economic activities. However, it also imposes a great burden on the environment through harmful emissions. As freight transportation demand is dependent mainly on economic activities, it is expected to increase further as the economy grows. It is estimated that overall domestic freight transportation demand will increase by about 196 per cent over the next twenty-year period. If the current trend continues, greenhouse gas emissions by the freight transport sector are expected to increase by about 190 per cent over the same period. However, with the construction of new railways and other planned major infrastructure projects, the share of rail in domestic freight transportation is expected to increase by 9.51 per cent, while the share of road transport is expected to decrease significantly during this period. This shift in modal shares could have a positive impact on greenhouse gas emissions, which may be reduced by about 6.54 per cent of the estimated total emissions from the transport sector.

Owing to the derived nature of demand, reducing the adverse environmental impacts of freight transportation is regarded as very difficult. The current policy measures for sustainable development in domestic freight transportation in the Republic of Korea focus mainly on a modal shift to environment-friendly modes. However, policies for increasing operational efficiency in freight transportation are also being pursued. These include the development of an integrated logistics information system, deregulation of the freight transport industry and standardization of logistics-related facilities and equipment. With the expected changes in modal shares brought about by these policy measures, energy consumption and the resulting adverse impacts on the environment could be significantly reduced.

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ASSESSING THE TRANSPORTATION PROBLEMS OF THE SUGAR CANE INDUSTRY IN THAILAND

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ABSTRACT

Transportation has a fundamental role in the economic development of all countries. It is not just a means to service commuting people, but also to collect products and materials from producers and distribute them to consumers. Transportation has become a significant factor affecting the production costs of commodities. The production of sugar cane in Thailand is no exception. The cost of transporting sugar cane from the farm gate to the mills is quite high, owing to the multiple transport facilities and time-consuming activities involved in the delivery process. The total transportation expenditure was estimated at 5,708 million baht for the crop year 1999-2000. The average cost per transaction incurred by farmers (excluding other labour costs) was in the range of 180-220 baht per ton in 1999. A large portion of this cost comprises truck rental and driver wages. These two elements together represent a high proportion of the overall production cost. The transportation issue has been overlooked in many industrial sectors and in the agricultural sector, in particular. The purpose of this paper is to present the findings of a study on the transportation and other relevant costs of sugar cane production. The findings and the subsequent recommendations could be considered for the enhancement of welfare of the sugar cane farmers and the increased efficiency of the industry in general and may also be applied to other agro-based industries facing similar problems.

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INTRODUCTION

Transportation is an essential element of the production-distribution chain. Delays in transportation are of serious concern since they affect production costs, which are eventually reflected in the consumer price. The present paper focuses on the assessment of transportation costs in the sugar cane industry, since they have been found to be very high in proportion to other variable costs. Owing to constraints, the study focuses only on the north-east region of Thailand. Data were collected through interviews with sugar-mill owners, sugar cane growers and truck operators. The study recommends a strategy for the establishment of an effective management mechanism in the delivery process of sugar cane products.

I. THE SUGAR INDUSTRY IN THAILAND

The sugar industry in Thailand has been growing rapidly, both in sugar cane production and in sugar mill expansion. Demand from domestic and international markets has been rising and has contributed to the economic growth of the nation. Sugar cane growing and processing into raw sugar is one of the largest industries in the country. Thailand is one of the largest sugar exporters in the world. The total export of white and raw sugar was 3.22 million tons in 2000. The Office of the Cane and Sugar Board under the Ministry of Industry has reported the total value of sugar exports for the crop-year 1998-1999 at 21.21 billion baht.

Cultivated in 5.62 million rais of land (1 hectare = 6.5 rais), total sugar cane production during the crop-year 1999-2000 was 53.10 million tons (see table 1), 20.26 per cent higher than the production of 44.17 million tons of the previous year. The Office of the Cane and Sugar Board reported total sales of sugar cane of nearly 24 billion baht for the crop-year 1999-2000. That year, the estimated cost of transportation for carrying sugar cane to the mills in the north-east was 2,379.18 million baht, which accounted for 41.68 per cent of the total transportation cost of sugar cane for the whole country (see table 2).

Table 1. Production of sugar cane and sugar, 1995/96-1999/2000

Year of production	Planting area (millions of rais)	Sugar cane (millions of tons)	Average yield (ton/rai)	Sweetness (CCS)[a/]	Sugar (millions of tons)	Sugar productivity (kg/ton)
1995/96	6.53	57.69	8.84	11.84	6.03	104.45
1996/97	5.89	56.24	9.56	11.78	5.82	103.47
1997/98	5.75	42.20	7.34	11.10	4.00	97.02
1998/99	5.45	44.17	8.10	11.66	5.20	103.72
1999/00	5.62	53.12	9.45	11.70	5.51	103.89

Source: Office of the Cane and Sugar Board, Ministry of Industry, Thailand.

a/ CCS is a measurement of sucrose content in cane, which can be refined into a form of white sugar if milling and purification processes are carried out according to standard procedures.

Table 2. Transportation costs of sugar cane by region in Thailand for the crop-year 1999-2000

Area	Sugar cane production (millions of tons)	Transportation costs (millions of baht)
North	10.71	1,065.22
Central	18.00	1,849.68
East	3.52	413.92
North-east	20.87	2,379.18
Total	53.10	5,708.00

Source: Office of the Cane and Sugar Board, Ministry of Industry, Thailand.

The price of sugar cane is based on the provisional price announced by the Government and the quality and sweetness as measured by Commercial Cane Sugar (CCS).[1] Cane with a higher CCS will fetch a higher price. In addition, the purity of the cane juice is also taken into account in setting the price. Freshly cut sugar cane has higher purity and produces more sugar than older sugar cane. Deterioration in the quality of sugar cane can also be caused by improper harvesting and delays during handling and transportation. These factors influence the price and thus the income of the sugar cane farmers.

II. STUDY RESULTS

The present study focuses on the operation of the sugar cane industry in the north-east region of Thailand, covering the provinces of Nakhon Phanom, Sakol Nakhon, Nong Khai, Udon Thani, Nong Bua Lam Phu, Loei, Mukdahan, Yasothon, Amnat Charoen, Kalasin, Khon Kaen, Maha Sarakam, Roi Et, Buri Ram, Chaiyaphum and Nakhon Ratchasima. The total sugar cane planting area in the region is 2.18 million rais. The region produced 21.51 million tons of sugar cane during the crop-year 1999-2000, representing 38.35 per cent of the country's total production. Udon Thani produced 5.23 million tons of sugar cane, making it the largest producing province in the region. Most of the cane-growing farms are owned and operated by individual families. It was also found that total transportation expenditure for the region was the highest in comparison to other regions.

[1] CCS is a measurement of sucrose content in cane, which can be refined into a form of white sugar if milling and purification processes are carried out according to standard procedures.

A. Cane and sugar industry in the north-east region

A total of 13 sugar mills are located in the seven provinces of Buri Ram, Udon Thani, Mukdahan, Kalasin, Khon Kaen, Chaiyaphum, and Nakhon Ratchasima of the north-east region.

The Office of the Cane and Sugar Board under the Ministry of Industry reported that during the crop-year 1998-1999 the most cultivated variety in this region was Phill 66-07, which occupied more than 40 per cent of the total planted area. The second most commonly cultivated variety was U-Thong I, which accounted for 13 per cent, and other varieties combined accounted for the remaining 47 per cent. The 13 sugar mills in the region processed 21.51 million tons of sugar cane into raw sugar (0.649 million tons), refined sugar (10.985 million tons), white refined sugar (2.843 million tons), and molasses (0.917 million tons) (see table 3).

Table 3. Total sugar production in the north--east region, 1999/2000

Mills	Raw sugar (tons)	Refined sugar (tons)	White refined sugar (tons)	Molasses (tons)
E-SAAN Sugar Industry	26,036	-	-	8,000
Mitr Phu Veang	34,324	1,278,167	-	83,524
Khon Kaen	107,799	909,615	800,705	108,507
Kumpawapi	82,331	628,302	113,080	66,121
Kaset Phol	56,265	560,934	-	62,410
Rerm Udom	68,927	892,258	-	72,774
Burirum	19,453	775,281	-	44,421
Saha Ruang	8,555	767,422	-	37,485
United Framer and Industry	62,186	906,859	976,736	91,121
Korat Industry	61,955	1,908,066	119,708	121,101
Ratchasima	95,614	641,339	400,045	90,236
Nong Yai	8,804	858,733	257,732	73,055
Mid Kalasin	16,496	857,723	174,944	58,014
Total	648,745	10,984,699	2,842,950	916,769

Source: Office of the Cane and Sugar Board, Ministry of Industry., Thailand.

B. Transport operations of sugar cane in the north-east region

Most sugar cane growers in the region are small farmers operating with their own families. Since most of them do not possess a truck and normally have only a small or a traditional multi-purpose vehicle, they have to pay the cost of transportation of the sugar cane from their farm to the mills. However, both small and large farmers face a common problem of transportation as the delivery of sugar cane per transaction requires a bulk carrier. They are required to rent a truck and pay hired labourers for cutting of sugarcane and loading the truck.

At the beginning and end of the season, the sugar mills face an inadequate supply of raw materials for crushing, whereas during the peak season supply is higher than the capacity of the mills. At that time hundreds of trucks can be seen queuing in front of the mills, waiting to unload sugar cane.

Truck owners normally operate their businesses as middlemen by charging for transport services per ton. They also face problems of delays during transportation and excessive time spent at the mills waiting to unload the raw sugar cane. Truck drivers might spend up to 24 hours for just one transaction. This, of course, has an impact on the cost of transportation. If the mills could manage the flow of trucks and unloading operations more efficiently, the cost of sugar production would be lower.

The study found that all of the three parties involved, that is, sugar mill owners, cane farmers and truck operators are affected by the problem of transportation, which eventually affects the cost of sugar production. It was found that the cost of transportation was high compared to other costs. In the crop-year 1999 the average cost of transportation in this region was 180-220 baht per ton.

C. The sugar cane delivery system

Both small and large farmers usually deliver sugar cane to the mills in either 10- or 6-wheel trucks which have legal loading limits of 21 tons and 10 tons respectively. However, trucks are always overloaded to keep down the cost of transportation and to maintain sugar cane quality. Many small growers cannot manage a bulk carriage by themselves and need to hire outside workers for help. The existing system has also led farmers to harvest prematurely in order to fill in the bulk capacity and thus economize on transportation. A worse situation occurs for small farmers operating far from the mills, who do not grow enough for a full truck load of sugar cane, which may eventually force them to give up growing sugar cane.

D. The high cost of production: cutting and loading

Table 4 below shows that labour costs represent slightly over 45 per cent of the total production cost per rai. Cutting and loading costs represent the highest portion of the variable cost. Since the transporting of raw materials requires bulk carriage, growers may not always have sufficient family members to do the work, forcing them to hire extra workers for cutting and loading. The labour cost for cutting and loading is estimated at 85 baht per ton, which is about 13-14 per cent of the total cost, but it can be even higher, depending on the number of cutting days required. Moreover, farmers have to pay at least 180-220 baht per ton in transportation costs, which are not dependent upon distance. Total labour costs for cutting, loading and transportation are in the range of 265-305 baht per ton. These costs represent 43-48 per cent of total costs and represent a significant proportion of the production costs for small and self-owned and operated families (see table 5).

Table 4. Cost of sugar cane production in the north-east region, crop-year 1999/2000

Items	Canes cultivated in first year (baht/rai)	Percentage of total production costs	Canes cultivated in second year (baht/rai)	Percentage of total production cost	Canes cultivated in third year (baht/rai)	Percentage of total production cost
Cutting and loading	1,071.49	21.05	781,09	32.42	819.39	34.39
Other labour costs	1,199.70	23.57	307.37	12.76	238.00	9.99
1. Total labour costs	2,271.19	44.63	1,088.46	45.17	1,057.39	44.37
2. Materials	1,812.39	35.61	630.31	26.16	603.33	25.32
3. Other variable costs	412.92	8.11	170.72	7.09	157.13	6.59
Total variable costs	4,496.50	88.36	1,889.49	78.42	1,817.85	76.29
1. Depreciation of agricultural tools	205.39	0.04	159.96	6.64	214.56	9.00
2. Land rental	387.15	7.61	360.1	14.94	350.52	14.71
3. Opportunity costs	0.02	0.00	0.02	0.00	0.02	0.00
Total fixed costs	592.56	11.64	520.08	21.58	565.10	23.71
Total production costs	5,089.06	100.00	2,409.57	100.00	2,382.95	100.00

Source: Office of the Cane and Sugar Board, Ministry of Industry, Thailand, survey carried out in 1999/2000-2001.
Note: The costs presented in this table do not include transportation.

Table 5. Average costs of sugar cane production in the north-east region, 1999/2000

Items	Average cost of cane production over three-year period (baht per rai)	Percentage of total production costs
1. Total labour costs	1,472.35	44.70
2. Materials	1,015.34	30.83
3. Other variable costs	246.92	7.50
Total variable costs	2,734.61	83.02
1. Depreciation of agricultural tools	193.30	5.87
2. Land rental	365.92	11.11
Total fixed costs	559.25	16.98
Production costs	**3,293.86**	**100.00**
Average output tons per rai: 7.75		
Average cutting and loading costs (baht/ton)	85.00	13.00-14.00
Average other costs	340.14	53.00-56.00
Cost of production (baht/ton)	425.14	66.00-70.00
Transportation costs (baht/ton)	180.00-220.00	30.00-34.00
Total costs (baht/ton)	**606.14-646.14**	**100.00**

Source: Office of the Cane and Sugar Board, Ministry of Industry, Thailand, survey carried out in 1999/2000-2001.

E. Queuing operations

Although most farmers in the region have contracts with certain mills, some trade and deliver sugar cane to any mill. However, they have to wait in a queue prior to unloading their sugar cane at the mill. Trucks unload on a first-come-first-serve basis. It may take up to 30 hours to complete the handling process, which raises the cost of transportation. To cut costs, farmers should have alternative choices of where they could deliver their product and thus change to mills with shorter queues. This kind of practice could, however, give rise to another problem. If sugar mills faced uncertainty as to whether they would be able to utilize their full capacity for crushing, they may resort to imposing higher prices in order to compensate for the uncertainty in supply of sugarcane from farmers.

III. THE LOADING STATION STRATEGY

The Office of Agricultural Economics under the Ministry of Agriculture and Cooperatives, in close cooperation with the sugar mill owners has developed a “loading station strategy” to reduce the costs of transportation in the sugar cane industry.

A “loading station” is an area prepared for loading activities. It should be located in the neighborhood of the growers in order to facilitate a smooth supply of cane to the mills and reduce the costs of transportation borne by the farmers. Currently, only one loading station has been established, in Khon Kaen Province. The station is owned and operated by a mill and is located just less than 100 km from it. The initial investment was approximately 11 million bath, which paid for the construction of facilities, the procurement of equipment such as an overhead crane and a weighbridge, and building and land costs. Over 80 per cent of the province’s sugar cane farmers use this facility and they deliver approximately 2,000-3,000 tons of sugar cane per day. Most of the farmers can rely on their own resources. The station also enables the mill to reach its target level of capacity utilization. The idea behind the loading station is to help small sugar cane growers to reduce their cutting and loading and transportation costs, which can represent 20 per cent or more of total costs. The decrease in costs means higher earnings for sugar cane farmers.

Figure 1 is a flow chart illustrating a loading station operation. Ideally, the loading station is a market trading spot for all sugar cane growers, and particularly for small farmers. They transport sugar cane from their farms to the station in their own vehicles and need only rely on family labour. The mill collects the sugar cane from the station and arranges onward transportation to the processing plant. Farmers pay a standard cost of 85 baht per ton to the mill for the transportation from the loading station to the processing plant. Under this new scheme, farmers and truck drivers save time and costs, since they no longer have to wait in line to deliver their product. Under the former, traditional system farmers delivered their product directly from their farms to the mills by bulk carriers and had to bear the whole cost themselves.

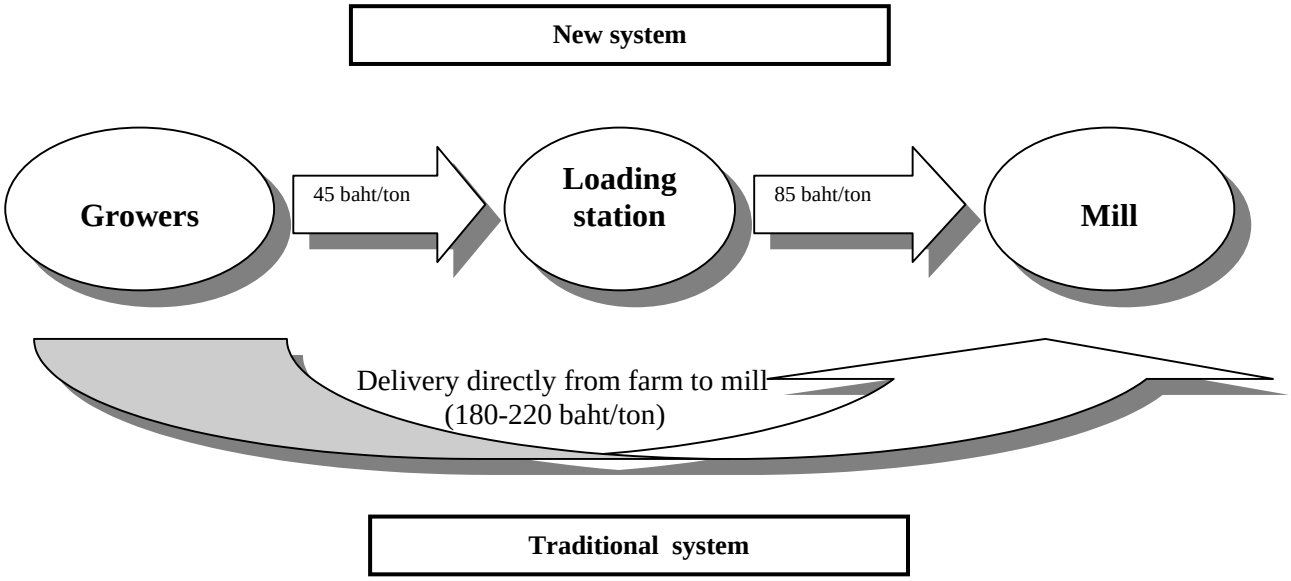

Figure 1. Loading station model: A cost-saving approach to sugar-cane transportation

There are three major benefits of supplying sugar cane to mills through loading stations. First, as already discussed, it reduces transportation costs significantly and can help maintain steady supplies of sugar cane to the mills. Second, it enables farmers to use land and other resources more efficiently and, by assuring them a higher income, encourages them to continue to grow sugar cane. Third, small farms owned and operated by family members can rely on their own labour for cutting and loading and thereby save at least another 85 baht per ton (see table 6).

Table 6. Comparison of sugar-cane transportation costs under the traditional system and the loading station system in north-east Thailand

Cost item	Traditional system (baht/ton)	Through loading station	
		Hired labour (baht/ton)	Own labour (baht/ton)
Cutting and loading	85	85	-
Cost of transportation from farm to station	-	45	45
Cost of Transportation from station to mill (charged by the mill)	-	85	85
Cost of Transportation from farm to mill	180-220	-	-
Total costs	265-305	215	130

The system of loading stations allows farmers to harvest a small amount of sugar cane at a time and use their own vehicles instead of renting a large truck. The loading station strategy also brings social benefits, as small farmers can operate and produce sugar cane by using their own family labour; they do not need to employ outside labour for cutting and loading since they can harvest little by little. In addition, they can find a market to sell their products more easily.

Owing to the fact that labour costs for cutting and loading are relatively high, the Office of Agricultural Economics and the Ministry of Agriculture and Cooperatives recommend vehicle- and labour-sharing among growers within a village for further savings in cost. Alternatively, the Government could consider providing loans to small farmers to buy trucks for use within the village and from farm to loading station. To obtain further benefits from loading stations, they could be managed through farmers' cooperatives or other suitable institutions that could protect the small farmers' interests.

CONCLUSIONS AND RECOMMENDATIONS

The success of the sugar cane industry in Thailand is built upon best practices in production, handling and marketing. However, further improvements in the overall efficiency of the industry and improvements in the welfare of sugar cane farmers are possible through a reduction in the transportation costs of sugar cane, which appears to be an important component of the total cost of production. Loading stations, which would benefit all the parties involved, that is, growers, truck operators, and mills, are proposed as a possible solution to the problem. Small farmers who rely on their own family labour would be expected to benefit the most from their introduction. A delivery system using loading stations has the potential to reduce transportation costs significantly and ensure better management of the supply chain. The system could also be considered for other similar agro-food sectors in Thailand. However, it is recommended that an in-depth study be undertaken to cover all regions in the country. A further study should also investigate the possibility of cooperation between agro-food industries for more efficient management of the supply chain.

THE EFFECTS OF PUBLIC TRUCK TERMINAL POLICIES ON AIR POLLUTION IN THE BANGKOK METROPOLITAN AREA

Kiyoshi Takahashi* and Ackchai Sirikupanichkul**

ABSTRACT

The present study was undertaken to examine the potential effects on air pollution and traffic movement in the city of the three newly established public truck terminals in Bangkok. The findings of the study reveal that the patterns of freight movement differ from one distribution channel to another. These channels are categorized as traditional trade, wholesale and retail markets, and modern trading through chains of superstores and convenience stores. An estimation of the emission loads from truck transportation was made by using empirical models and the geographic information system. The findings show that oxides of nitrogen (NO_x) are the major emission load generated from trucks (61.73 tons per day), followed by carbon monoxide (CO) (37.72 tons per day). Emissions of NO_x from heavy-duty diesel vehicles (HDDV) are approximately twice as high as those from light-duty diesel trucks (LDDT), despite the fact that the vehicle kilometre travel (VKT) of LDDTs is 7.3 times higher than that of HDDVs. Finally, the potential effects of truck restriction policies on air pollution after the establishment of public truck terminals are assessed through simulation studies. The results of simulation show that such truck terminals could help decrease VKT of HDDVs, but would increase VKT of LDDTs. Consequently, the terminals could help reduce emission loads of NO_x by 825 per cent and Suspended Particulate Matter (SPM) by 860 per cent from their present levels. However, emission loads of CO and hydrocarbons (HC) would be higher owing to the increase in VKT of LDDTs. This increase in levels of CO and HC is not so important, since the number of LDDTs in Bangkok is much smaller than the number of cars, which generate much higher volumes of CO and HC. The current 24-hour truck restriction on the Outer Ring Road core is more effective in reducing NO_x and SPM than that on the Inner Ring Road core. Further policies need to be formulated to promote the usage of truck terminals, which can lead to further reductions of NO_x and SPM.

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I. OVERVIEW

Most of the freight traffic in Bangkok is generated by conventional wholesale and retail markets, private truck terminals, freight forwarders, factories and modern trade. The conventional wholesale markets are usually located inside the Inner Ring Road core. Most of the markets are categorized by type of goods: flower, vegetables, clothing, and so forth. These markets are under the management of either the Bangkok Metropolitan Administration (BMA) or the private sector. Recently, the construction of inner and outer ring road networks has made it possible to introduce large-scale, modern wholesale markets in suburban areas of Bangkok such as Simoom Muang and Talad Thai. At these markets agricultural products from other regions, are traded. The Government supports and promotes them because of their potentials to reduce the freight traffic volume in central areas of Bangkok. They provide more systematic and larger storage and handling areas for the massive volume of goods from the provinces.

Non-perishable goods such as clothing, groceries and processed foods are traded mainly inside the city. Commercial buildings are utilized as storehouses. Traffic volumes and the frequency of loading and unloading activities generated by these markets are less than those generated by markets of perishable goods, since non-perishable commodities can be kept in storage for longer periods. However, most of the trucks used in the wholesale markets are of medium and large types (6- and 10-wheeled trucks). The major problem of the wholesale markets is the lack of parking space. As a result, some loading and unloading activities take place at the roadside which obstructs the passage of other road users. The construction of multi-storey structures is one solution to the parking problem of these markets, for it could provide more space for parking and cargo storage. Other problems of the markets include poor accessibility and problems caused by truck ban regulations.

The conventional retail markets are scattered all over Bangkok, especially in residential and commercial areas. They are usually open from early morning until midday. Goods are transferred from these markets to vendors, hawkers, restaurants, hotels, hospitals, and supermarkets in small vehicles. Some markets are called “talad nud”, where various commodities such as vegetables, fruits, clothes, plants, pets, and so forth are sold on specific days fixed by the market manager. Several foreign companies have introduced modern trading through chains of superstores and convenience stores. Freight forwarding and logistics systems play an important role in this type of trading. The transport operations serving this type of trading are more efficient than the two other types discussed earlier. Interested readers are referred to Sirikijpanichkul (2000) for more details about freight forwarding and logistics operations in Bangkok.

The rapid economic growth and urban sprawl of Bangkok have resulted in higher volumes of inner city freight transportation. The increased usage of trucks, especially heavy trucks, has a major impact on traffic conditions, road safety and the environment of the city. To address the negative effects of heavy truck movements, the Government has formulated a number of truck operation policies and taken other measures. Time-based truck restrictions, zonal restrictions, and three suburban truck terminals have been introduced in order to restrict heavy trucks from entering the inner city. However, these policies and measures have strengthened the role of smaller trucks and vans in transporting goods in inner Bangkok.

The main objective of this study was to examine the effects of the new public truck terminals on air pollution in Bangkok. The paper is organized as follows: the first section provides an overview of present freight transportation arrangements in Bangkok, a statement of the problem and the objectives of the study. The second section is a review of the literature concerning a freight transportation model, an emission model and previous studies. The freight transportation plans and policies for Bangkok are presented in the third section. The results of the estimation of emission loads from existing truck-based freight transportation are presented in the fourth section. The fifth section summarizes the possible effects on emission loads after the introduction of public truck terminals in Bangkok. Finally, conclusions are drawn and some recommendations are presented for consideration by the concerned authorities.

II. LITERATURE REVIEW

A. Freight transportation model

There are differences between the forecasting models used in urban freight transportation planning and the ones used in urban transportation planning, although the process of modelling may be similar. The major problem in developing an urban freight transport demand model is the lack of freight movement data at all spatial levels. The availability of appropriate data directly affects the choice of techniques (Memmott 1983). A number of actors are involved in freight transportion, such as industrial firms, shippers, carriers and logistics service providers, which is another factor that complicates freight transport demand modelling.

There are two basic types of model that can represent traffic flow on road networks: traffic assignment models and traffic simulation models. The traffic assignment models have a limited range of applications owing to their inherent theoretical properties. The simulation models are further classified into two types: micro-simulation models such as NETSIM (network simulator) (Lieberman 1981) and macro-simulation models such as CONTRAM (contiuous traffic assignment model) (Leonard and Gower 1982). Some other types of model were also developed to represent the relationship between performance of road systems and other factors: for example, congestion functions to indicate the relationship between demand and performance of a road system. In this type, link cost function and cost models provide information on the cost of transporting goods by alternative routes, and by using different terminals and different types of vehicle (Jara Diaz 1982).

Most of the freight demand models developed have followed the conventional four-step modelling process, with some adaptations specific to freight, such as the models developed by Van Es in 1982, Kim and Hinkle in 1982, Friesz, Tobin and Harker in 1983 and Harker in 1985 (Ortúzar and Willumsen 1996). The models can be either trip-based or goods-flow based. Boerkamps and Binsbergen (1999) suggest that the trip-based models are not able to evaluate new transport systems. For goods-flow based models, goods flows are modelled based on their production or distribution, or both, and consumption points (shops or consumers). A vehicle-loading model assigns goods flows from origin to comsumption points. Finally, the flows are assigned to the road network.

B. Emission model

The diesel engine is a major source of air pollution owing to exhaust emissions of oxides of nitrogen (NO_x), carbon monoxide (CO), Suspended Particulate Matter (SPM), sulphur dioxide (SO_2) and volatile organic compounds (VOCs). The high levels of NO_x emissions from heavy-duty vehicles are explained by the characteristics of diesel engines: they run at higher combustion chamber pressures and temperatures than petrol engines. The conditions of combustion are conducive to high levels of NO_x emissions. SPM in diesel exhaust originates mainly from unburned fuel and engine oil (Weaver and Klausmeier 1988 and Conte 1990).

Studies have been carried out to investigate the relationship between road traffic operating conditions and emission loads. Two main emission models developed in the United States of America are currently in use: the Enviromental Protection Agency Mobile Source Emission Factor Model (EPA MOBILE), which is the most widely used, and the California Air Resources Board Emission Factor Model (CARB EMFAC), which is used in California. The structures of both models are the same. Activity-specific emission rates estimated by the models are multiplied by vehicle activities to provide emission outputs by pollutant (that is, grams per vehicle-mile for MOBILE and grams per vehicle-hour and per vehicle trip for EMFAC) (Guensler 1993). Baseline emission rates are derived from a laboratory test procedure known as the federal test procedure (FTP). The FTP driving cycle consists of a sequence of accelerations, decelerations, cruise speeds and idling based on actual home-to-work commuter trips in the 1960s on Los Angeles freeways and surface arterials (EPA 1993).

C. Previous studies in Bangkok

Emissions from on-road vehicles can be determined from vehicle mileage travel (VMT) and the emission factors of pollutants. Hanson and Lopez (1992) estimated the emission factors of CO. Later, Boontherawara (1994) developed the emission factors of NO_x, which depend on temperature, vapour pressure, speed, operating mode, altitude, age of vehicle, and so on. However, the most important determining factor of the emission rate is vehicle speed (EPA 1996). Chulalongkorn University conducted a study to develop an emission database as an input to the "Airviro" computer program. The database of Airviro can be updated and used to estimate the emission load and its dispersion. The road network and traffic data needed for the program include hourly volume, traffic composition, speed, and average daily traffic (ADT). The emission load is finally estimated by the program from data on fuel consumption, traffic characteristics and VKT (Pollution Control Department 1994).

Tanadtang (1999) conducted a study on the effects of traffic on air quality through driving cycle tests by measuring and evaluating the exhaust emissions of petrol vehicles on congested and uncongested roads, suburban roads and expressways in Bangkok. Muttamara and Leong (2000) measured exhaust emissions from petrol vehicles in Bangkok by chassis dynamometer. A fleet of 10 vehicles of different models, years and manufacturers was selected for the purpose of measuring air pollutants in exhaust fumes. They found that average CO and HC emissions from 1990-1992 cars were 32.3-64.2 and 1.82-2.98 gm per km respectively and decreased to 17.8-40.71 and 0.75-1.88 gm per km respectively for the newer 1994-1995 cars. The results also indicated that air pollutant emissions significantly increase with increases in mileage and the age of the car. The study

also confirmed that there is a correlation between average air pollutant concentration and traffic speed.

III. FREIGHT TRANSPORTATION PLANS AND POLICIES IN BANGKOK

The restriction of truck movements was the first measure implemented to reduce the traffic load of heavy trucks in Bangkok. Restrictions have been in place since 1989. Four- and six-wheeled trucks are prohibited from entering the Bangkok metropolitan area at the peak hours of between 6 and 9 in the morning and 4 and 8 in the evening. Ten-wheeled and larger trucks have extended hours of restriction: they are banned between 6 and 10 in the morning and 3 and 9 in the evening. However, on-street parking of heavy trucks during the unrestricted hours continues to have adverse effects on other road users. To alleviate this problem, public truck terminals were proposed in 1969, and feasibility studies on truck terminals were subsequently carried out. These studies also considered land acquisition problems, the possibility of granting concessions to the private sector and the construction process. Finally, three public truck terminals were constructed and opened for operation in June 2000. These three public truck terminals are located in the north (Pathumthani), the east (Ladkrabang), and the west (Buddha Monthon) of Bangkok, as shown in figure 1. The truck terminals are aimed at reducing the number of heavy trucks and the enhancement of the air quality in the city area. Since the introduction of the three terminals there have been some significant changes in truck ban measures: in addition to the existing policy of restriction by hours of the day, new bans have been proposed based on spatial zones, defined by the Outer and Inner Ring Roads.

The zonal truck-ban policy is to be implemented in four phases. In the first phase, all trucks with 10 wheels or more were not allowed to park inside the 45-sq-km truck-free zone of Bangkok, as shown in figure 2. This was implemented in June 2000. This truck-free zone was extended up to the Inner Ring Road (113-sq-km) in September 2000 in the second phase. Finally, trucks with 10 wheels or more will be totally prohibited from entering the Inner and Outer Ring Road areas in the third and fourth phases respectively. However, as these bans could seriously affect the truck operators located inside the city, the Department of Land Transport has requested the Ministry of Industry to conduct a study on the movements of commodities in the inner areas, the location of truck operators and their fleets and other matters that could be adversely affected in the third and fourth phases of zonal truck bans. The study would, inter alia, identify the preventive measures to address the negative effects on freight operations caused by the proposed bans in the last two phases.

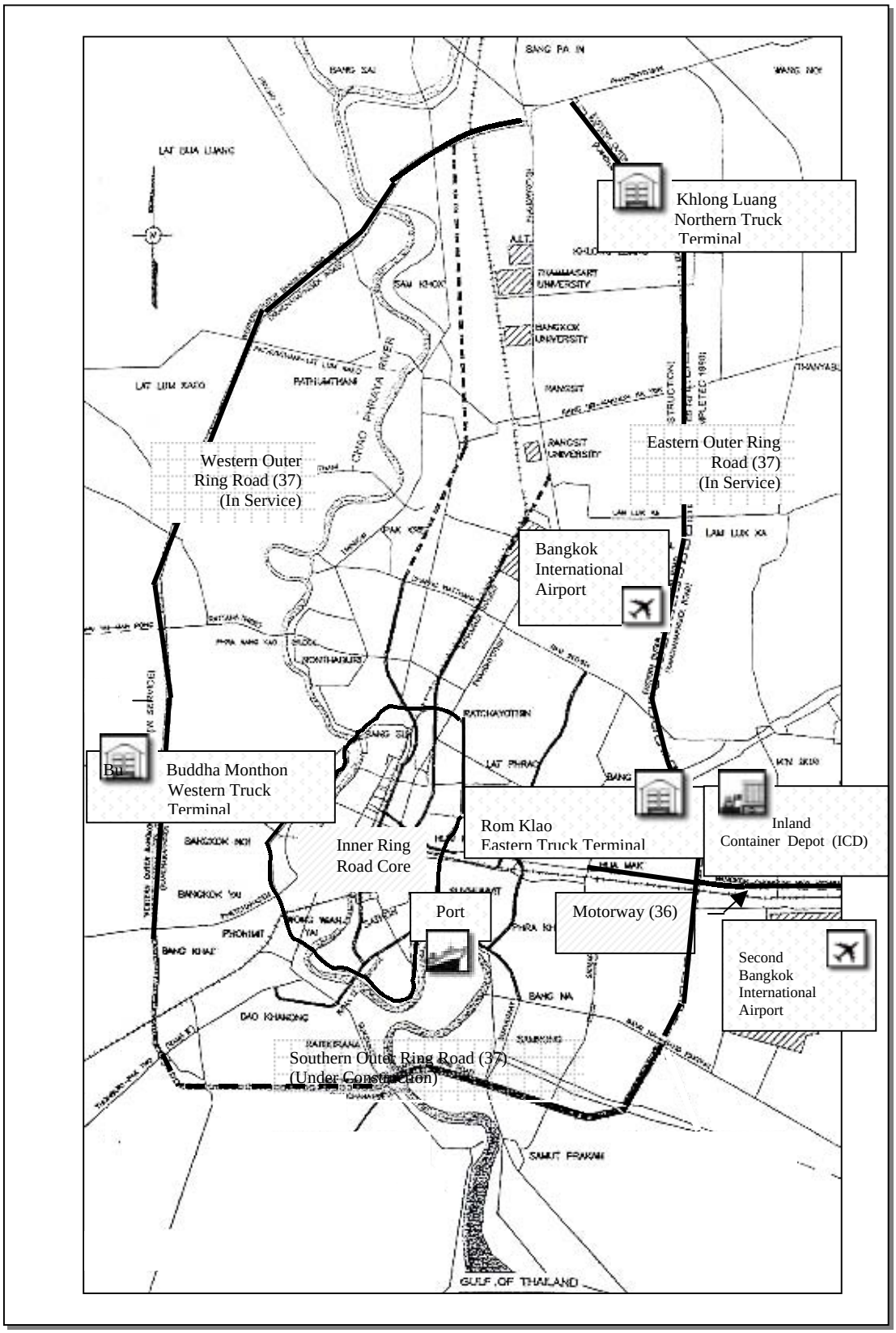


Figure 1. Inner and Outer Ring Roads, ports and freight terminals in Bangkok

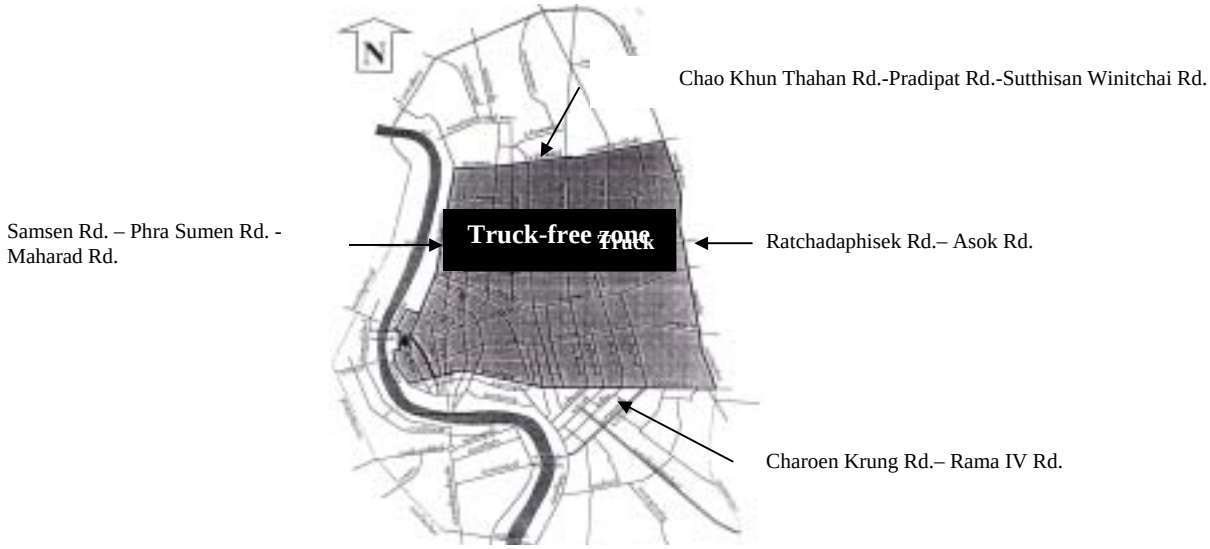


Figure 2. Truck-free zone implemented in June 2000

Besides zonal restrictions, some truck routes have been designated to enable truck access to ports and freight terminals located within the restricted area. Such routes include the Outer Ring Road and all links between ports and expressway access roads (Department of Land Transport 1999a).

IV. ESTIMATION OF EMISSION LOADS FROM TRUCK-BASED FREIGHT TRANSPORTATION IN BANGKOK

A. Data collection

In order to estimate emission loads from truck-based freight transportation, a study was carried out, including all 50 administrative districts of Bangkok. They were encoded to simplify the origin-destination (O-D) study. Twelve major markets and two private truck terminals were selected as survey locations for the collection of data on freight movement and other related information through a questionnaire. The selection of the survey locations was based on size, location and type of market, as shown in table 1.

After defining the survey locations, a questionnaire was designed. General questions and those on freight transportation data and freight transportation problems were incorporated. The general questions related to the type of business (retail, wholesale, factory, farm and garden, freight forwarder, or other); the type of commodity (vegetables, clothes and leather, fresh food, fruits, processed foods, meat and fish, flowers, rice, sugar and flour, manufactured products, or other); and the type of vehicle (pick-up, 4-, 6- or 10-wheeled truck, or van). Freight transportation data included distance travelled per day and per week, origin and destination, number of trips per day, age of vehicle, trip frequency per week, refuelling, load factor, loading and unloading time, and travel time.

Table 1. Emission load survey locations by type of market

No	Location *		Size of market		
	Outer Ring Road Core	Inner Ring Road Core	Large (over 20,000 sq. m)	Medium (5,001 – 20,000 sq. m)	Small (less than 5,000 sq. m)
1	Inside	Inside	-	4 (3 wholesale, 1 weekend)	2 (1wholesale, 1 private truck terminal)
2	Inside	On	-	1 (wholesale)	-
3	Inside	Outside	1 (wholesale)	-	3 (weekend)
4	On	Outside	-	1 (retail market)	-
5	Outside	Outside	-	-	2 (1 weekend market, 1 private truck terminal)
Total			**14**		

Notes: * See locations of Outer and Inner Ring Road in figure 1.

One thousand two hundred (1200) questionnaires were distributed and collected from truck users at 14 survey locations in November and December 1999. After screening, 910 valid questionnaires were accepted for analysis.

Data collected from secondary sources included truck registration numbers from 1981 to 1999, emission factors of LDDTs and HDDVs, and the estimated number of trucks using the public truck terminals. These data were obtained from the Department of Land Transport (1999b), the Pollution Control Department (1994), and the Japan International Cooperation Agency (1992) respectively. Geographic information on Bangkok from SmartMap^{TM} (a GIS-based program) was applied to estimate VKT. There are two methods to estimate VKT: the average daily traffic (ADT) method and the method based on a distance-travelled analysis. The second was selected for this study because of the lack of the necessary traffic data for the first method. For travel time, the interview technique was applied. The whole process of data analysis is shown in figure 3.

B. Some general characteristics of freight traffic

It was found that the small pick-up truck was the major type of vehicle used in freight transportation (93.8 per cent), followed by 6-wheeled trucks (4.2 per cent). Other types formed the rest. Most of the trucks carried goods from factories, wholesalers, and warehouses and truck terminals to vendors, fresh markets and retail or grocery shops. The load factor of trucks carrying manufactured products was highest (88.3 per cent), followed by fruits (85.9 per cent), and clothes and leather (82.8 per cent). In terms of origin, trucks from factories had the highest load factor (88.4 per cent), followed by trucks from warehouses or truck terminals (88.1 per cent) and wholesalers (86.8 per cent).

The peak hours for truck movements to and from fresh markets were between 5 and 8 in the morning. For processed food and clothes markets as well as private truck terminals, the peak hours were between 10 and 12 in the morning.

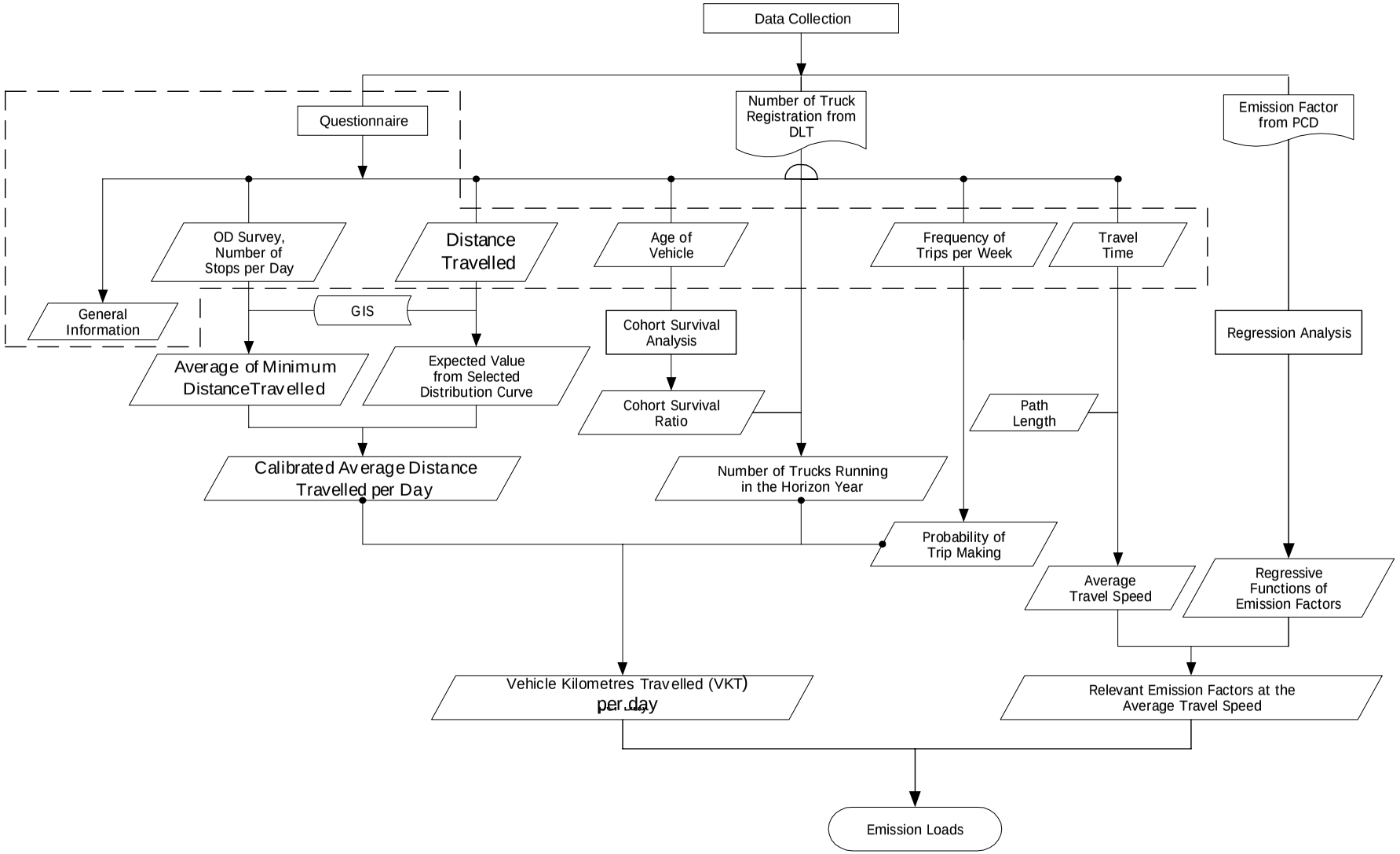


Figure 3. The process of data analysis in emission load survey

Note: DLT: Department of Land Transport; GIS: geographic information system: OD: origin-destination; PCD: Pollution Control Department

C. Estimation of vehicle kilometer travel

VKT and travel speed are the two important parameters for the estimation of emission loads. In this study, data on distance travelled per day was validated by Chi-square ($\chi 2$) goodness-of-fit test. A logarithmic normal distribution model best fitted the collected data. Reference is made to Sirikijpanichkul (2000) for details on the model. The average value was 74.761 kilometres at 0.05 significance level. It was verified later by using GIS. A distance matrix of Bangkok was established using SmartMap. This matrix was developed to provide distances between each pair of the 50 administrative areas in Bangkok based on their assumed central reference positions. An O-D table developed from the survey was then overlapped on the matrix. Consequently, the average shortest distance per trip was obtained. The average shortest distance travelled per day was calculated from the average number of trips per day multiplied by the average shortest distance per trip. The analysis shows that the average shortest distance of travel per day is 33.504 kilometres. When disaggregated by type of vehicle, the modelled average travel distances of LDDTs and HDDVs were found to be 53.700 and 63.119 kilometres respectively.

The age of vehicle and trip frequency per week were used as inputs for estimating the number of trucks running in the base year (1999). A survival rate matrix for different age groups of trucks was developed by using the cohort survival technique (Ortúzar and Willumsen 1996). The matrix of truck population by age and for each category was developed from the vehicle registration data. To get the estimated number of trucks by category in the base year, the survival rate matrix was multiplied by the truck population matrix. Summation of the numbers of truck in both the categories gave the estimated total number of trucks running in 1999.

The data on trip frequency per week were used for the calculation of probability of trip-making by a truck. Finally, VKT per day for HDDVs and LDDTs were calculated by multiplying the modelled average distance travelled per day for each category by the corresponding number of trucks running in the base year and their probability of trip-making as shown in table 3.

Table 2. Number of truck registrations from 1983 to 1999

Year	Number of truck registrations	Number of heavy-duty diesel vehicles	Number of light-duty diesel trucks	Increase in number of heavy-duty diesel vehicles	Increase in number of light-duty diesel trucks
1999	788,493	118,656	669,837	14,112	75,220
1998	699,161	104,544	594,617	-5,910	41,782
1997	663,289	110,454	552,835	3,657	98,595
1996	561,037	106,797	454,240	15,370	51,560
1995	494,107	91,427	402,680	8,177	78,778
1994	407,152	83,250	323,902	-7,099	51,712
1993	362,539	90,349	272,190	5,401	80,282
1992	276,856	84,948	191,908	2,938	41,977
1991	231,941	82,010	149,931	-26,096	63,725
1990	194,312	108,106	86,206	22,716	8,807
1989	162,789	85,390	77,399	5,544	20,866
1988	136,379	79,846	56,533	11,835	10,290
1987	114,254	68,011	46,243	2,433	16,103
1986	95,718	65,578	30,140	1,663	13,865
1985	80,190	63,915	16,275	9,721	3,289
1984	67,180	54,194	12,986	2,354	8,545
1983	56,281	51,840	4,441	-	-

Source: Department of Land Transport (1999).

Table 3. Calculation of vehicle kilometres travelled per day by the estimated number of trucks running in 1999

Vehicle type	Number of trucks running in 1999 (1)	Probability of trip-making (2)	Average distance travelled per day (kilometres per day) (3)	Vehicle kilometres travel per day (vehicle–kilometres per day) (4) = (1) x (2) x (3)
LDDT	342,194	0.7761	53.700	14,261,472
HDDV	40,755	0.7594	63.119	1,953,492

D. Estimation of emission loads

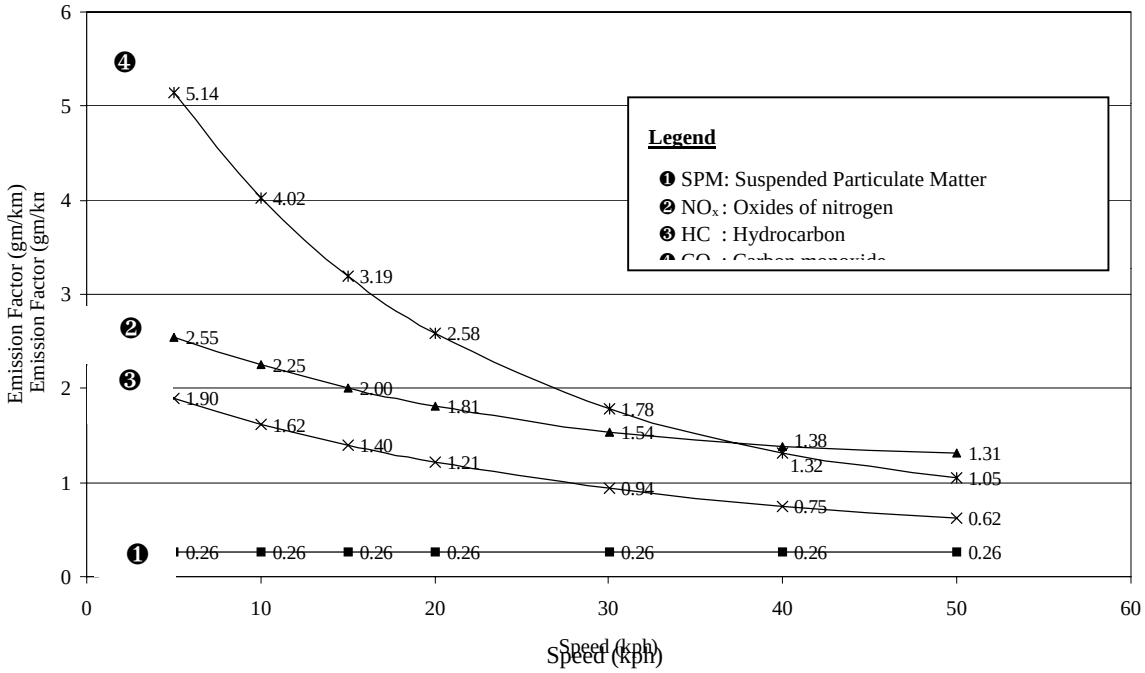
The emission factor (in grams per kilometre) of each pollutant depends on the type of vehicle and the travel speed. Sources of emission were broadly categorized into LDDT (pick-up truck and van) and HDDV (6- and 10-wheeled trucks). In this study, travel speed was calculated from distance travelled and travel time. Distance travelled was obtained by tracing the route of O-D survey data on a GIS database. Data on travel time was collected from the questionnaire. A logarithmic normal distribution model was fitted to the estimated travel speed. The model was validated by Chi-square ($\chi 2$) goodness-of-fit test. The average value was 36.22 kilometres per hour at 0.05 significance level. The average travel speeds of LDDTs and HDDVs were 36.07 and 39.37 kilometres per hour respectively. The average speed of HDDVs was higher than that of LDDTs owing to the fact that HDDVs could enter the city only during off-peak hours.

The emission factor of each pollutant was obtained from emission factor charts developed by the Pollution Control Department (1994) as shown in figure 4. It was assumed that emission factors would be similar to those based on the driving conditions as used in the above mentioned study by the Pollution Control Department. The emission loads were finally calculated by multiplying VKT per day by the corresponding emission factors at the average travel speed. The results of emission load estimation are shown in table 4.

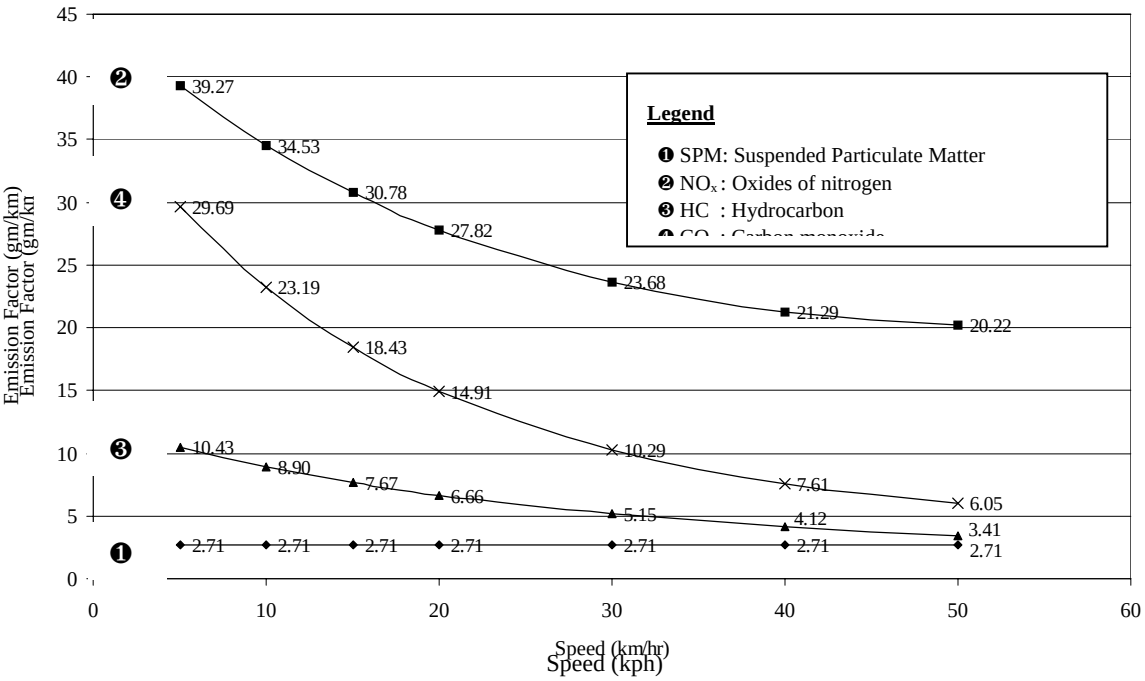
As shown in table 4, NO_x is the major emission load generated by HDDVs, followed by CO, HC and SPM, in that order. On the other hand, LDDTs emit CO at the highest level, followed by NO_x, HC and SPM.

HDDVs generate very high levels of NO_x. It is noteworthy that the total NO_x generated by HDDVs is approximately double that of LDDTs, despite the fact that the mileage of LDDTs is 7.3 times higher than HDDVs. Total SPM from HDDVs is also much higher than that from LDDTs.

Light-duty diesel trucks
LDDT



Heavy-duty diesel vehicles
HDDV



Source: Pollution Control Department, Thailand (1994).

Figure 4. Emission factors of light-duty diesel trucks and heavy-duty diesel vehicles

Table 4. Emission load generated by trucks running in the Bangkok Metropolitan Area

Vehicle class	VKT per day	Average travel speed (kph)	Emission factor (grams per vehicle kilometre)		Emission load (kilograms per day)
Light-duty diesel trucks (pick-up truck and van)	14,261,472	36.07	CO	1.5481	22,078
			NO_x	1.4416	20,559
			HC	0.7583	10,814
			SPM	0.2600	3,708
Heavy-duty diesel vehicle (6- and 10-wheeled trucks)	1,953,492	39.37	NO_x	21.0747	41,169
			CO	8.0073	15,642
			HC	4.0497	7,911
			SPM	2.7100	5,294

V. THE POTENTIAL EFFECTS OF PUBLIC TRUCK TERMINALS ON EMISSION LOADS

The estimated number of truck trips from the three public truck terminals in the year 2000 was used for the calculation of emission loads. The Japan International Cooperation Agency (1992) simulated five scenarios based on the proposed truck ban measures after the opening of the truck terminals. The scenarios were as follows:

Case 1: existing condition with 2.8 per cent use ratio.
Case 2a: 24-hour heavy truck restriction in the inner area with 100 per cent use ratio.
Case 2b: 24-hour heavy truck restriction in the inner area with 2.8 per cent use ratio.
Case 3a: 24-hour heavy truck restriction in the outer area with 100 per cent use ratio.
Case 3b: 24-hour heavy truck restriction in the outer area with 2.8 per cent use ratio.

The predicted number of truck trips using each public truck terminal in the year 2000 is shown in table 5 (JICA 1992). Four commodity types were considered in the study: processed food, clothes and leather, manufacturing products and miscellaneous goods. After the opening of the truck terminals, the number of heavy trucks running inside Bangkok would reduce. However, the number of delivery trucks (LDDTs) transporting goods from truck terminals to destinations inside Bangkok would increase. In addition, the distance travelled by LDDTs would also increase, owing to the longer average distances between the truck terminals and destinations inside the metropolitan area than before.

The three public truck terminals are located in the Don Muang, Thavee Watthana and Ladkrabang areas respectively. From the distance matrix, distance ratios were calculated by dividing the average distance between Don Muang, Thavee Watthana and Ladkrabang and the other administrative areas by the average distance between all administrative areas. For example, the ratio of distance for the northern public truck

terminal North is $\frac{21.752}{16.234} = 1.3399$. The average distance travelled per day for 1.6 ton delivery trucks and the distance ratio at each terminal are shown in table 5.

Table 5. Distance travelled per day of delivery trucks using three public truck terminals

Scenario	Truck terminal	Number of 1.6 ton delivery trucks (vehicle trips per day)	Percentage of 1.6 ton delivery trucks using each terminal	Distance ratio	Existing distance travelled per day (km/day)	Adjusted distance travelled per day (km/day)
(1)	(2)	(3)	(4)	(5)	(6)	(7) = (5) x (6)
Case 1	North	1,454	40.45	1.3399	57.789	77.432
	West	1,054	29.32	1.4004		80.928
	East	1,087	30.23	1.6399		94.766
	Total	3,596	100.00		Average	83.697
Case 2a	North	7,181	37.08	1.3399	57.789	77.432
	West	4,828	24.93	1.4004		80.928
	East	7,357	37.99	1.6399		94.766
	Total	19,367	100.00		Average	84.886
Case 2b	North	5,956	36.74	1.3399	57.789	77.432
	West	4,073	25.13	1.4004		80.928
	East	6,182	38.13	1.6399		94.766
	Total	16,211	100.00		Average	84.920
Case 3a	North	14,049	42.35	1.3399	57.789	77.432
	West	9,336	28.14	1.4004		80.928
	East	9,791	29.51	1.6399		94.766
	Total	33,176	100.00		Average	83.532
Case 3b	North	11,529	42.30	1.3399	57.789	77.432
	West	7,679	28.17	1.4004		80.928
	East	8,049	29.53	1.6399		94.766
	Total	27,258	100.00		Average	83.536

Source: Japan International Cooperation Agency 1992.

The possible effects of truck terminals on vehicle mileage and emission loads are presented in tables 6 and 7. It is observed that after the implementation of public truck terminals, the mileage of HDDVs would slightly decrease, while the mileage of LDDTs would greatly increase. The results also show that the truck terminals could reduce emission loads of NO_x and SPM in Bangkok owing to the lower mileage of HDDVs. However, emission loads of CO and HC would significantly increase, owing to the increased mileage of smaller delivery trucks.

The results also indicate that a 24-hour truck restriction on the Outer Ring Road core would be more effective in reducing NO_x and SPM emissions than a restriction on the Inner Ring Road. The percentage of emission reduction, however, depends on truck terminal usage. The higher the usage of the truck terminal, the larger is the potential emission reduction.

Table 6. Estimation of increased vehicle-kilometres travelled per day of delivery trucks and heavy trucks for each truck ban scenario

Vehicle type/ scenario	Estimated number of truck trips using public truck terminals	Average distance travelled per day (kilometres per day)	Increased vehicle kilometres per day
Delivery Truck (1.6 Tons per vehicle)			
Case 1	3,596	83.697	300,942
Case 2a	19,367	84.886	1,643,971
Case 2b	16,211	84.920	1,376,666
Case 3a	33,176	83.532	2,771,265
Case 3b	27,258	83.536	2,276,978
Heavy Truck (10.5 tons per vehicle)			
Case 1	548	63.119	-34,583
Case 2a	2,951	63.119	-186,273
Case 2b	2,470	63.119	-155,922
Case 3a	5,055	63.119	-319,094
Case 3b	4,154	63.119	-262,166

Source: Japan International Cooperation Agency 1992.

Table 7. Net increment of NO_x, CO, HC and SPM (in kilograms per day) after the introduction of public truck terminals in Bangkok

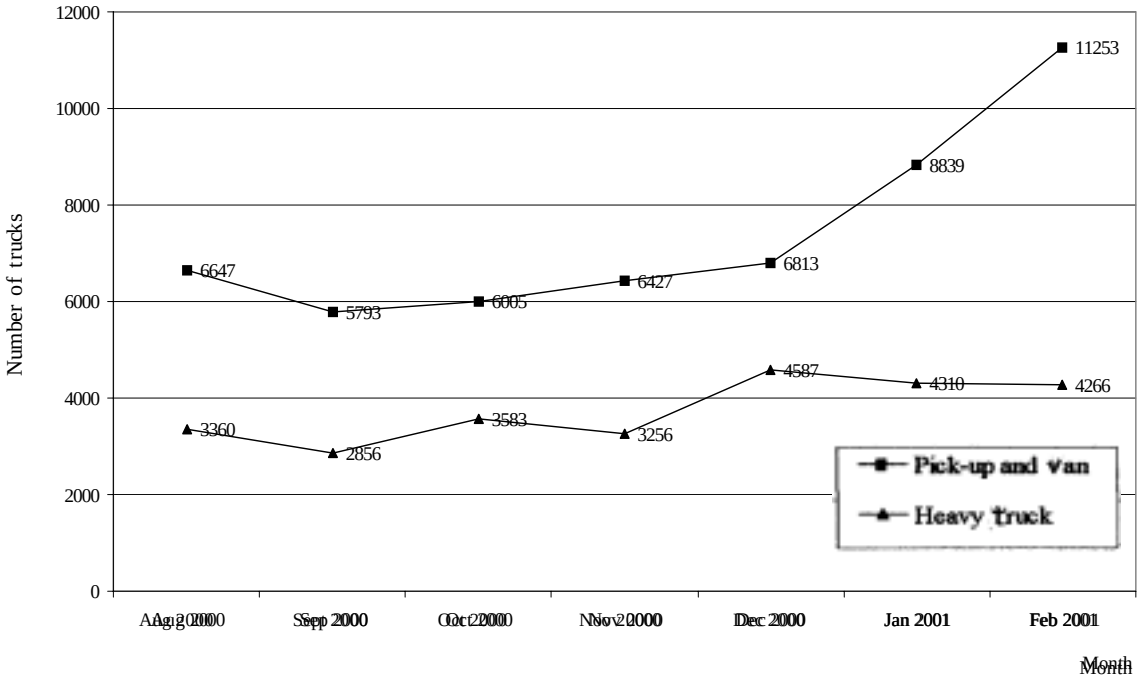
Scenario	NO_x	CO	HC	SPM
Case 1	-295	189	88	-15
Case 2b	-1,301 (-341)	883 (+367)	412 (+368)	-65 (-333)
Case 2a	-1,556 (-427)	1,053 (+457)	492 (+459)	-77 (-413)
Case 3b	-2,243 (-660)	1,426 (+654)	665 (+656)	-118 (-687)
Case 3a	-2,730 (-825)	1,735 (+818)	809 (+819)	-144 (-860)

Note: The figures in parentheses indicate the change in emission load compared with the case 1 scenario.

CONCLUSIONS AND RECOMMENDATIONS

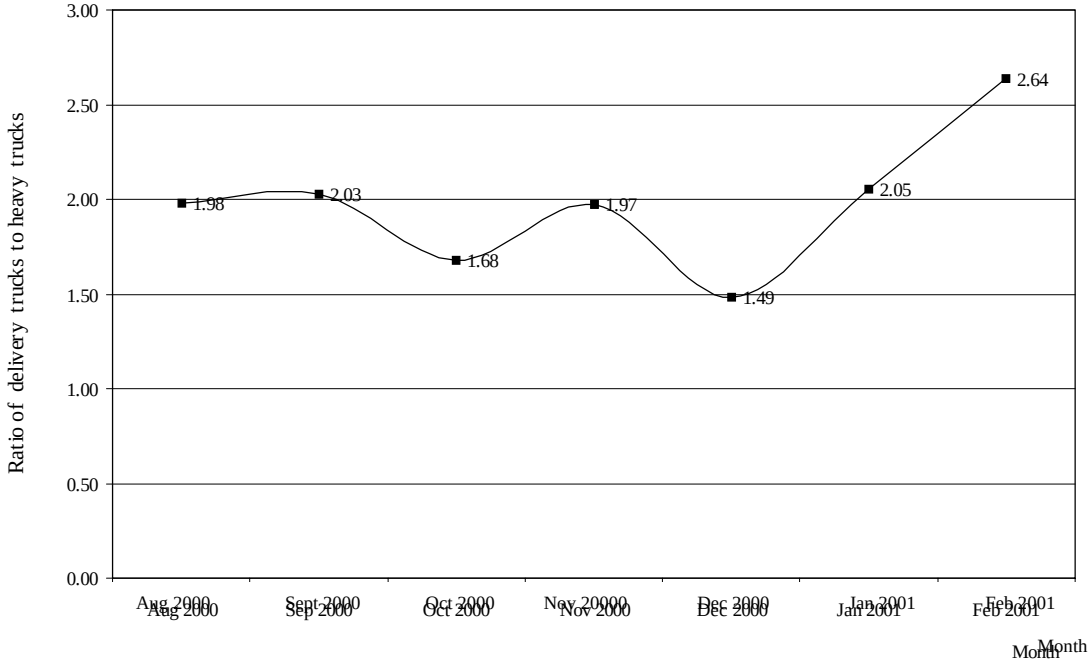
This study was conducted to examine the possible effects of public truck terminals on traffic movement and the environment of Bangkok. An estimation of the emission loads from truck transportation was made by using empirical models and the geographic information system.

The findings of the study show that NO_x are the major emission load generated by trucks (61.73 tons per day), followed by CO (37.72 tons per day). NO_x emissions from heavy-duty diesel vehicles are approximately double those from light-duty diesel trucks, despite the mileage of LDDTs being 7.3 times higher than the mileage of HDDVs. The public truck terminals could have a considerable impact on the air quality of Bangkok. They would slightly decrease the mileage of HDDVs, but increase the mileage of LDDTs. This could help reduce emission loads of NO_x by as much as 825 per cent and SPM by 860 per cent from their respective base levels. However, emission loads of CO and HC would become much higher, owing to the increased mileage of smaller delivery trucks. However, the overall impact of increases in emission loads of CO and HC is not expected to be very significant as there are fewer diesel pick-up trucks in Bangkok than cars, which generate much higher volumes of CO and HC (Department of Land Transport 1999b). The 24-hour truck restriction on the Outer Ring Road core is more effective in reducing NO_x and SPM than the restriction on the Inner Ring Road.



Source: Department of Land Transport, Thailand (2001).

Figure 5. Number of delivery trucks and heavy trucks using the western public truck terminal from August 2000 to February 2001



Source: Department of Land Transport, Thailand (2001)

Figure 6. Ratio of delivery trucks to heavy trucks using the western public truck terminal from August 2000 to February 2001

In addition, the higher the usage of the truck terminal, the greater is the reduction in NO_x and SPM.

The study reveals some promising positive effects of the truck terminals. However, some problems are challenging the success of this policy. Terminal usage is not as high as was originally predicted. The most serious problem faced by the truck operators is the increase in operating costs. They claim that additional costs include terminal rental cost, parking fees, the purchasing of new delivery trucks, and so forth. The number of delivery trucks using the western public truck terminal in December 2000 was 220 vehicles per day, which was only 5.4 per cent of the predicted volume for Case 2b of table 6. Nevertheless, the number of delivery trucks using the terminals increased sharply in the following months. It is observed that the ratio of delivery trucks to heavy trucks using the truck terminals also rose, as shown in figure 6. This trend indicates the consolidation of cargo handling. Since greater usage of the truck terminals could contribute to significant improvements in air quality in Bangkok, actions need to be considered to promote their usage. To enhance the usage of public truck terminals further, some measures may be considered as follows:

(a) The Government could encourage factories in inner areas to move out to industrial zones established near the public truck terminals. If needed, new zones could be established by the Government to ensure a reasonable land price and the availability of all the necessary physical infrastructure;

(b) Logistics facilities for chilled and frozen goods could be developed in public truck terminals;

(c) The road network and other infrastructure facilities linking the truck terminals and industrial zones could be improved to provide greater accessibility, wider coverage and faster movement.

The lessons learned should be useful for the proposed regional truck terminals in different parts of the country, which include truck terminals in the north at Chiang Mai, in central Thailand at Nakhon Sawan, in the north-east at Khon Kaen and Nakhon Ratchasima, and in the south at Had Yai and Songkhla.

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