The Economic and Environmental Assessment of Thailand's Rail Transport Investment

Gritsana Patjakreng* and Sompote Kunnoot**

Abstract

In the present study a CGE model was used to assess Thailand's plan for rail transport investment in terms of changes in the economy and regarding CO_2 emissions. Aggregate economic impact is described in terms of change in real GDP and a number of macro indicators. Economic impacts also involve change in the economic structure created by differences in the strength of change at the micro level. Environmental impact is expressed in terms of change in CO_2 emissions, coupled with the petroleum consumption of different production. Change in petroleum consumption is brought about by changes in the components of the economic system at macro and micro levels. This study found that rail investment produces a positive change in real GDP, which summarizes both the appreciation and depreciation of economic components. Moreover, rail investment induced a shift in the transportation method in favor of rail transport, which is allegedly regarded as more energy efficient. The saving of CO_2 emissions is a product of this shift. Understanding potential economic and environmental impacts contributes to confidence and rationale for rail investment.

Keywords: Rail Transport, Fuel Efficiency, CGE Model, CO_2 Emissions

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* 90/62 Soi On-nuch 17 Yaek 16, Suan Luang, Suan Luang, Bangkok 10250, THAILAND.
E-mail: gritsanalucky@gmail.com

** School of Environmental Development Administration, National Institute of Development Administration
118 Moo 3, Sereethai Road, Klong-Chan, Bangkapi, Bangkok 10240, THAILAND.
E-mail: skunnoot@yahoo.com

การประเมินผลทางด้านเศรษฐกิจและสิ่งแวดล้อม จากการลงทุนโครงสร้างพื้นฐานการขนส่ง ทางรางของประเทศไทย

กฤษณะ แพทย์จะเกร็ง* และ สมพจน์ กรรณนุช**

บทคัดย่อ

การศึกษานี้เป็นการประยุกต์ใช้แบบจำลองคำนวณดุลยภาพทั่วไปเพื่อประเมินผลการเปลี่ยนแปลงทางด้านเศรษฐกิจและสิ่งแวดล้อมจากการลงทุนโครงสร้างพื้นฐานการขนส่งทางราง ซึ่งสามารถสะท้อนผ่านการเปลี่ยนแปลงของผลิตภัณฑ์มวลรวมภายในประเทศที่แท้จริงและปริมาณการปล่อยก๊าซคาร์บอนไดออกไซด์ที่เกิดจากการบริโภคน้ำมันเชื้อเพลิง การลงทุนโครงสร้างพื้นฐานการขนส่งทางรางส่งผลให้เศรษฐกิจโดยรวมของประเทศเติบโตมากขึ้นซึ่งเป็นผลมาจากการที่ต้นทุนและราคาของสินค้าและบริการในระบบเศรษฐกิจโดยรวมลดลง ในขณะเดียวกันยังส่งผลประโยชน์ให้การใช้น้ำมันเชื้อเพลิงในภาคการขนส่งมีประสิทธิภาพมากขึ้น เนื่องจากมีการปรับเปลี่ยนรูปแบบจากการขนส่งทางถนนมาสู่การขนส่งทางรางเพิ่มขึ้น ทั้งนี้ประสิทธิภาพการใช้น้ำมันเชื้อเพลิงที่สูงขึ้นยังส่งผลให้ปริมาณการปล่อยก๊าซคาร์บอนไดออกไซด์ลดลงซึ่งแปรผันตามปริมาณการบริโภคน้ำมันเชื้อเพลิง ดังนั้น การลงทุนโครงสร้างพื้นฐานการขนส่งทางรางจึงมีผลประโยชน์ทั้งทางด้านเศรษฐกิจและสิ่งแวดล้อม และสามารถนำไปใช้เป็นแนวทางในการกำหนดนโยบายการลงทุนของภาครัฐที่มีการพิจารณาถึงผลกระทบทางด้านเศรษฐกิจและสิ่งแวดล้อม

คำสำคัญ: การขนส่งทางราง ประสิทธิภาพการใช้น้ำมัน แบบจำลองคำนวณดุลยภาพทั่วไป การปล่อยก๊าซคาร์บอนไดออกไซด์

* 90/62 ซอยอ่อนนุช 17 แยก 16 แขวงสวนหลวง เขตสวนหลวง กรุงเทพมหานคร 10250
อีเมล์: gritsanalucky@gmail.com

** คณะบริหารการพัฒนาสิ่งแวดล้อม สถาบันบัณฑิตพัฒนบริหารศาสตร์
118 หมู่ 3 ถนนเสรีไทย แขวงคลองจั่น เขตบางกะปิ กรุงเทพมหานคร 10240
อีเมล์: skunnoot@yahoo.com

Introduction

Thailand's rail transport system has been neglected for more than 40 years. The railway network of Thailand in 2014 covered the total distance of 4,043 kilometers, including the service areas of 47 provinces. Most of the network, 3,763 kilometers, is single track (93%); 173 kilometers (4%) are double-track; and 107 kilometers (3%) are triple-track. A considerable amount of time is often used for stopping at the track transfer station (OTP, 2014). Limited and delayed maintenance of cars, tracks, and equipment and facilities are the main sources of the incidence of failures and increased frequency of accidents. Over 60% of the tracks are over 30 years old and only 65% of the locomotives, most of which are very old, are in use (OTP, 2011 and TDRI, 2012). The whole system has suffered from deterioration as prolonged under-budget maintenance has eroded the integrity of the equipment over the period.

The transportation mix is biased in favor of road transport. Thailand's freight structure for the period of 2004-2012 is shown in Figure 1. Average domestic freight shipment using roads, air, inland waterways, and coastal and rail transport accounted for 74.37%, 9.47%, 7.88%, 6.25%, and 2.03% of the total volume, respectively (MOT, 2014). The increase in the road networks connecting regions and rural areas has been responsible for the larger share of road transportation.

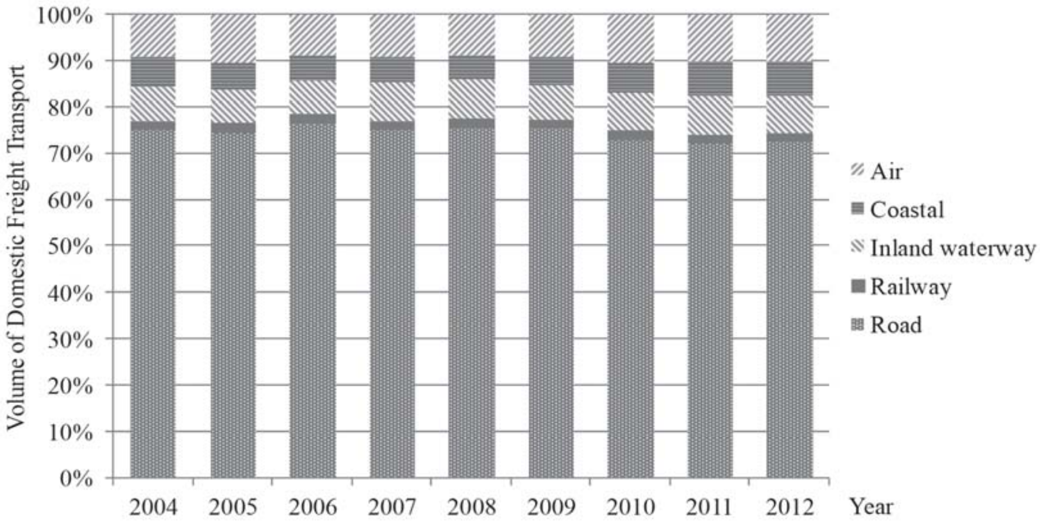

Figure 1: Domestic Freight Transport Ratio by Mode

Source: MOT, 2014

Technically, total transport cost is best optimized when the marginal cost of the different modes of transport are equalized. Analysis of the marginal cost equalization for the whole transportation system is possible only when a computable general equilibrium model is used (Barrios et al., 2013; Kockelman et al., 2013; and Robson & Dixit, 2015). However, it is quite reasonable to assume that a significant difference exists between the marginal cost of rail transport and other mode of transport due to the observed deterioration of the rail transport operation and the absence of a rail development initiative.

The absence of rail development can be explained according to the nature of the state-owned enterprise, which is guided by public policy. Failure to take into account the whole picture of the transport system can be considered a product of the absence of coordination (TDRI, 2013). Only recently were a national committee and supporting bureau created to oversee the whole picture of the transportation system. Still rail system development remains in delay.

The difficulty of revitalized rail development can be speculatively attributable to sizable investment outlays. Large-size investment is time consuming because of the debates and discussions in political arena, and because of media interrogation and public scrutiny. It usually cannot be concluded before the end of the government term. Change in the ruling party and political contests are a primary reason for the continued absence of long-term development. For instance, on November 25, 2014, the water resource management programs costing 324,606 million Baht approved by the previous government were cancelled by the Cabinet of the new government (Royal Thai Government Gazette, 2015). The program was replaced by a new solution for water resource management and flooding problems which cost much less. Political competition, which is based on short-life political-term performance, requires the use of a budget that has a shorter life than long-term investment. Political party policies have become an overriding practice in government administration for the purpose of election (Holcombe, 1989; and Skilling & Zeckhauser 2002). It is not certain whether popular policies are consistent with efficiency-oriented public interest. Political contests represent a pressure for political parties to prefer piecemeal policies to long-term planning policies. This nature of political competition explains the absence of the use of deliberative and integrated longer-term planning, which can offer the notion of total efficiency (Bardhan and Yang, 2004; and Boulding & Brown, 2012).

Greater use of rail transport is intuitively understood as having the ability to improve total fuel efficiency (ERIA, 2010 and Janic & Vleuge, 2012). The purpose of this study is to evaluate investment in rail transport in terms of fuel efficiency, and consequently, environmental performance for the whole transport system in Thailand. The use of a computable general equilibrium (CGE) model enables the research to evaluate investment in rail transport on the basis of the equi-marginal principle. The general equilibrium of the market achieved by free the movement of the price of goods and factors assures efficient distribution between sectors.

Transportation and logistic infrastructures play an important role in economic development (Banister & Berechman, 2001; Laird et al., 2005; and Sakamoto, 2012). Infrastructure development has assured the basic connectivity and access to gateways for most developing countries (World Bank, 2014). Freight transportation that arranges the proper mix of road and rail is an essential means by which the gain of economic development is obtained with minimum negative environmental and social impacts (Van Ierland et al., 2000; Woodburn, 2003; Kim et al., 2011; and Reis et al., 2012). Figure 2 shows that the domestic freight shipment in China, Germany, India, Japan, Korea, the United Kingdom, and the United States using rail transport accounts for 17.60%, 22.79%, 33.97%, 4.85%, 6.36%, 10.24% and 35.20% of total volume, respectively (International Transport Forum, 2015).

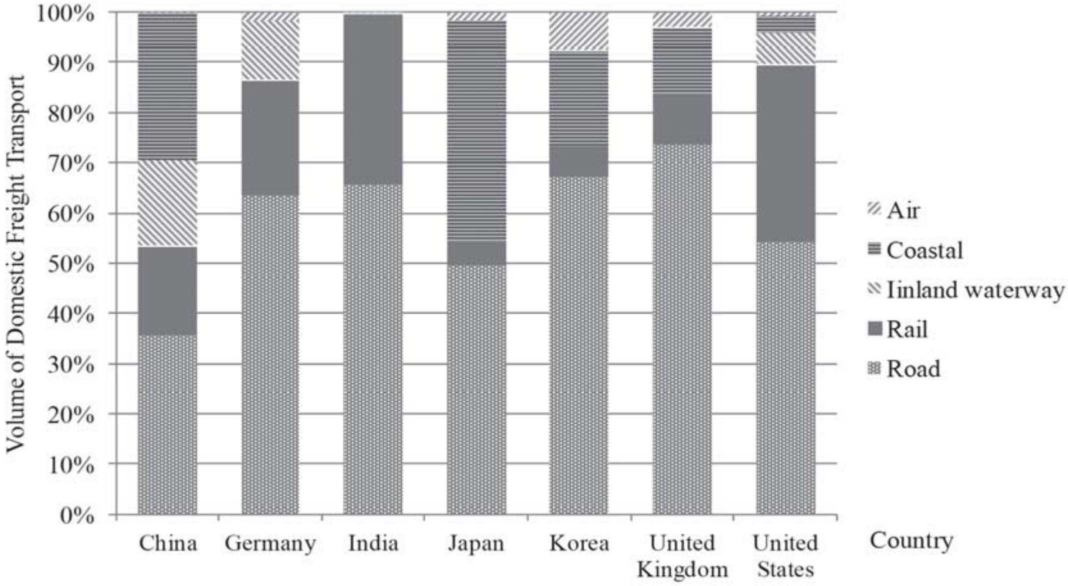

Figure 2: Freight Railway Transport in OECD Countries

Source: International Transport Forum, 2015

The challenge for Thailand involves addressing the issues including spatial infrastructure development connecting urban and rural areas (OTP, 2009), in which the whole of the transport system is deliberately considered. Thailand is in an advantageous position in terms of benefiting from the liberalization of trade regarding the goods and services, investment, and labor mobility offered by the ASEAN Economic Community (AEC) (ERIA, 2010). Thailand's competitiveness can be enhanced by internal strengths, including macroeconomic stability, having a large domestic market, inexpensive labor, and the availability of infrastructure. The renewal of rail transport development can be seen as a strategy to exploit geographical advantage, as Thailand is placed at the center among the countries of South East Asia (Royal Thai Government, 2012). This location gives Thailand an opportunity to be a gateway for Laos and Southern China, and to become the transportation hub of South East Asia. Railway development can serve as a primary mode of transport with road transport serving as a feeder (TDRI, 2012).

The evaluation of rail transport development in terms of true cost is not applicable, as rail transport is a state enterprise. Many aspects are included in the assessment, which involves price policy, non-financial attributes, social benefits and costs, large investment, property ownership, land acquisition, and many special privileges, including route design. Accordingly, rail transport capital can be seen as indivisible. This nature grants the rail transport system the right of a natural monopoly. For socially optimal reasons, the state enterprise is regarded as a proper channel for the administration of a monopoly enterprise (Stiglitz, 2002).

The government administration of rail transport is a two-sided coin. Rail transport development can benefit from proactive government authority for all of the required arrangements. On the other hand, the rail transport system can suffer from the complete neglect of a non-initiative government (TDRI, 2009). As a state enterprise, rail investment is rather motivated by policy than financial return. A number of issues are generally discussed concerning a state enterprise. These encompass inefficiency, public debt burden, subsidized prices, poor innovation, and deteriorating services. In this study, a positive view of rail development is assumed based on the existing structure of customers. The evaluation of the economic and environmental changes that have arisen from the investment discussed in this study, however, has not included the issue of the management platform. Different management structures used by the metropolitan railway system in Thailand can offer an analytical comparison.

Rail transport has gained renewed attention as logistics issues have become an important part of competitiveness development and improvement. Improving logistics performance is at the core of the economic growth and competitiveness agenda. World Bank (2014) insisted that policymakers globally recognize the logistics sector as one of their key pillars for development. According to World Economic Forum (2014) the extensive and efficient infrastructure is critical for ensuring the effective functioning of the economy, as it is an important factor in determining the location of economic activity and the kinds of activities or sectors that can develop within a country.

The evaluation of rail transport investment can provide evidence for gaining support. It is intended to measure the extent of economic impacts, to describe the changes in economic structure, and to trace environmental consequences. A significant part of environmental issues can be addressed by paying attention to transport development (Button, 1993). Rail transport is known to be more energy efficient relative to other mode of land transport (Woodburn et al., 2008; ERIA, 2010; Motraghi, 2012 and Reis et al., 2012).

Rail transport produces 3 times less carbon dioxide emission than road transport. In terms of quantity, moving one ton of cargo for one kilometer involves the release of 21 grams of carbon dioxide using rail transport compared to 59 grams using road transport (World Shipping Council, 2009). Environmental performance is better achieved by better fuel efficiency.

In economics, maximum efficiency is achieved through the equalization of the marginal cost of different systems of transportation which determines the amount of output for each system. The opposite is concentration on a certain mode, which will deliver sub-optimal efficiency. Total efficiency is a channel for assuring minimum environmental impact. A system of marginal cost equalization is best described using a computable general equilibrium model.

The Model Structure

In the modern land transportation system, which primarily consists of roads and rail, the substitution is possible within a limited degree. In the context of the continued growth of the human population, the economy, and urbanization, passenger and freight traffic requires increased investment. The transportation system in Thailand has been biased in favor of road transport, as investment in rail transport involves a large-scale budget and government policy. The favorable attribute of rail transport is more competitive freight costs in exchange for large investment. For the investment of public funds to have the greatest positive effects, government agencies need to employ the most suitable ways to assess the economic benefits arising from transport projects. Wang and Charles (2010) suggested that this is clearly necessary so as to ascertain whether these projects sufficiently justify their cost, or whether the funds would be better spent elsewhere, including on competing transport-related projects. Some of the impacts of the transport system play themselves out over a long period of time and, as a result, can result in fundamental changes in the economic structure. These impacts involve complex patterns of interaction between economic variables.

The transport sector as a whole is a major energy user. The rail transport is known to have important attributes in terms of comparatively more energy efficiency. The rail transport can be sufficiently evaluated in terms of economic impacts and environmental impacts. The economic impacts are measured in terms of their contribution to real GDP.

Likewise, the environmental impacts are measured in terms of the total emission of carbon dioxide and other components of greenhouse gases.

The direct environmental impacts of transport are linked to energy consumption. These are the emissions of greenhouse gases, including CO_2, SO_2, CO, dust, and particles (OECD, 2010). Energy-efficient rail transport offers two types of benefit: increased transport volume and decreased emission. The increased transport volume and energy cost savings are accounted for in terms of economic benefit. The total benefits are measured by the change in the gross domestic product (GDP).

In this approach, the examination of the economic and environmental impacts from transportation structural change consists of two main steps: (1) calculation of the economic impacts from the investment in rail transport infrastructure; and (2) the calculation of environmental costs in terms of the amount of carbon emission.

The CGE model was customized based on the ORANI tradition (Dixon et al., 1982). The CGE model was specified to be consistent with Thailand's input-output table released by The Office of National Economic and Social Development Board (NESDB). The system is specified to consist of 60 goods and services. The 58-sector version of Thailand's input-output table was reclassified to disaggregate two sectors, including road transport and rail transport, for the purpose of this study. The new input-output table became 60 sectors. The isolation of rail transport made it possible for the investigation of the impacts of investment in rail transport on the whole economy. Likewise, the isolation of land transport served to enable the discovery of the changes in the transportation mix between road transport and rail transport as a result of the changes in rail transport. Environmental consequences were the subject for investigation concerning the impact of investment on rail transport. The environmental impact can be described in terms of the change in carbon emissions following changes in the economy. Energy consumption following economic change is described in terms of energy-real GDP elasticity, the ratio between the percentage change in energy use and the percentage change in real GDP.

The production function was configured with a two-level nest as shown in Figure 3. The first level applied the Leontief form in combining intermediate input, primary inputs, and indirect tax. The second level applied the Cobb-Douglas substitution

(CD) in combining domestically-produced and imported intermediate inputs, and in combining labor and capital inputs.

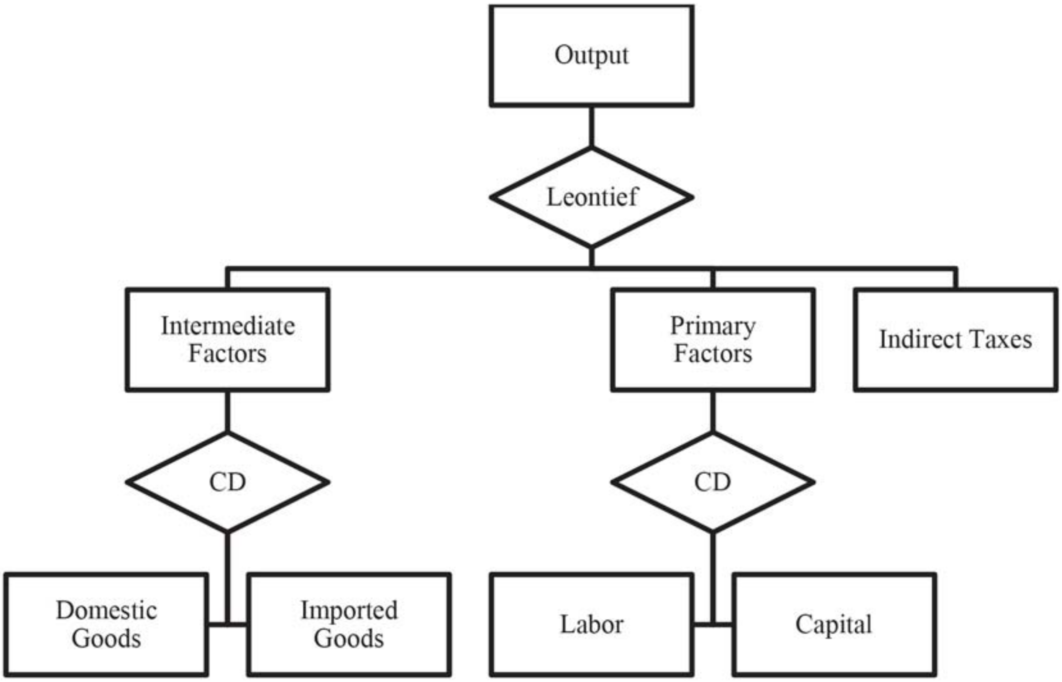

Figure 3: Composite Production Functions

The final demand component of the CGE model consists of household consumption, investment consumption, government consumption, and export. The behavior regarding household consumption was specified by Cobb-Douglas utility maximization[1]. The behavior of investment expenditure was specified by Cobb-Douglas

[1] Utility maximization expression
$C = P_1X_1 + P_2X_2$; for C = Budget, P_1 and P_2 = Price of goods 1 and 2, and X_1 and X_2 = Quantity of goods 1 and 2
$U = X1^{\alpha}, X2^{\beta}$; for U = Utility, α = share parameter for X_1 , and β = share parameter for X_2
Lagrangian maximization function is given by $Max: L = X1^{\alpha}, X2^{\beta} + \lambda[C - (P_1X_1 + P_2X_2)]$;
First order condition for X_1, X_2, λ can be obtained as:

$$\frac{\partial L}{\partial X_1} = \frac{\alpha U}{X_1} - \lambda \cdot P_1$$

$$\frac{\partial L}{\partial X_2} = \frac{\beta U}{X_2} - \lambda \cdot P_2$$

$$\frac{\partial L}{\partial \lambda} = C - P_1 \cdot X_1 - P_2 \cdot X_2$$

The behavior for X_1 and X_2 is found as $X1 = \frac{\alpha C}{P_1}$ and $X2 = \frac{\beta C}{P_2}$

cost minimization[2]. The behavior of government spending was specified by Cobb-Douglas' utility maximization. Exports were specified by the inverse relationship between export price and export demand. Exports were also positively related to foreign income. For the present study, foreign income was assumed to be unchanged. The nominal GDP propensity to spend for households, investors, and government was assumed to be fixed. Accordingly, the nominal budget for households, investors, and government was proportionately fixed with nominal GDP.

The capital accumulation of the CGE model was specified as return induced (Dixon et al., 1982), as shown in Figure 4. The ratio $K1/K0$ was inversely related to the ratio $1/R0$. Future capital stock $K1$ was the sum of current capital stock less depreciation and current investment. Current return $R0$ was the difference between capital rental price and the cost of capital goods production. The future rate of return was a constant value. It follows that $R1/R0$ falls as $R0$ rises. Investment demand increases as the current rate of return $R0$ increases. One possibility for an increase in the current rate of return was the increase in the capital rental price, which may be driven by economic growth. The other possibility for an increase in the current rate of return was the decrease in the cost of capital goods production, which may be driven by technological progress.

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[2] Cost minimization expression

$C = P_K K + P_L L$; for C = Cost, P_K = Capital rental price, P_L= Wage rate, K= Quantity of capital, L = Quantity of l

$Q = A(K^{\alpha}, L^{\beta})$; for Q = Output, A = Total factor efficiency, α = share parameter for K , and β = share parameter f

Lagrangian minimization function is given by $Min: G = P_K K + P_L L + \lambda[Q - (K^{\alpha}, L^{\beta})]$;

First order condition for K, L, λ can be obtained as:

$$\frac{\partial G}{\partial K} = P_K - \lambda\alpha \cdot \frac{Q}{K}$$

$$\frac{\partial G}{\partial L} = P_L - \lambda\beta \cdot \frac{Q}{L}$$

$$\frac{\partial G}{\partial \lambda} = Q - (K^{\alpha}, L^{\beta})$$

The behavior for K and L is found as

$$K = \frac{Q}{P_K} P_K^{\alpha}, P_L^{\beta}$$

$$L = \frac{Q}{P_L} P_K^{\alpha}, P_L^{\beta}$$

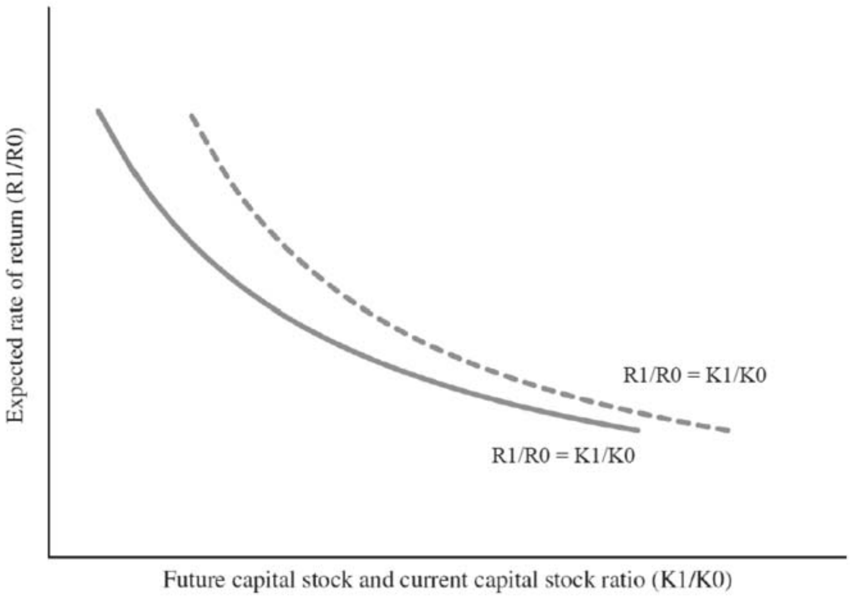

Figure 4: Conceptualization of Investment Behavior

The environmental cost was measured in terms of the quantity of carbon dioxide emissions across the economy due to the change in the rail transportation system. In this study, the calculation of CO_2 emissions using the emission factor required four components, consisting of average petroleum prices in 2013, the petroleum consumption ratio of gasoline and diesel, the CO_2 emission factor, and total petroleum value change. The quantity of CO_2 emissions was determined by CO_2 per liter of gasoline and diesel, which was 0.00232 metric tons and 0.00267 metric tons (EPA, 2005; IPCC, 2006; and EPA, 2013).

The Model Simulations

This study employed the CGE model as the tool for the accounting of economic impacts and environmental consequences. The CGE model consisted of 16,414 variables and 15,933 equations, thus leaving 481 variables exogenous. The increase in rail transport investment was input into the CGE system. Change in real GDP was used as the description of total economic impacts and change in total petroleum consumption was used as the coupling to environmental impact. The value of change in energy consumption was converted to the physical quantity of pollutants as carbon emission.

The study of the impacts of rail investment consisted of 2 stages. First, the economic changes in period T were produced solely by rail investment in period T-1. The distribution of investment across the economic sectors of the economy was a product of the economic changes in period T. In the second stage, economic changes in period T+1 were produced by investment of all sectors during period T. The economic changes in period T+1 were considered secondary impacts. The accounting of the initial impacts was separated from the secondary impacts in order to compare the strengths of the two impacts.

Thailand's national infrastructure, particularly its transport network, is set to undergo a long-awaited transformation over the coming eight years, following the approval of a 2.4 trillion Baht master plan by the National Council for Peace and Order (NCPO). The approval consists of projects known as the "Strategies on Thailand's Infrastructure Development in Transportation (2014-2022)." The railway development consists of double-track rails. Phase I (2015-2018) is planned to cover three lines: (1) Thanon Chira junction-Khon Kean; (2) Prachuap Khiri Khan-Chumphon; and (3) Nakhon Pathom-Hua Hin. The total outlay for the double track development project amounts to 63,338 million Baht (OTP, 2014). Compared with the total assets of the State Railway of Thailand, which amounts to 164,387 million (SEPO, 2015), the investment cost accounts for 38.53% of total assets.

Results

Macroeconomic Results

As shown in Table 1, rail transport investment is projected to contribute a 0.002704% increase to real GDP in period T and 0.000669% in period T+1. The driver for real GDP growth is the fall in the cost of rail transport, which will raise the cost competitiveness of goods and services, increase output, and increase value-added. Economic growth is driven by negative inflation, shown as a GDP deflator value of -0.001995% in period T and 0.000091% in period T+1. Inflation in period T is produced by excess demand over capital supply constraint in period T+1.

Table 1: Percentage Change in Macroeconomic Variables

Variable	Period T	Period T+1
Consumer Price Index	-0.001705	0.000082
Investment Price Index	-0.001041	0.000098
Government Consumption Price Index	-0.002605	0.000173
Total Value of Labor Input	-0.021319	0.000828
Total Value of Capital Input	0.011059	0.000715
Total Value of Indirect Taxes	0.017291	0.000835
Total Value of Exports	0.003763	0.001760
Total Value of Imports	0.003073	0.001534
Exchange Rate	-0.001032	0.000033
Change in Trade Balance-GDP Ratio	0	0
Income-side Nominal DGP	0.000709	0.000761
Expenditure-side Nominal GDP	0.000709	0.000761
GDP Deflator	-0.001995	0.000091
Real GDP	0.002704	0.000669

The increased supply of capital in the railway sector initiates a fall in the cost of rail transport, which is transmitted to a fall in the price of goods and services across the economy through linkages in connection with rail transport. The increase in real GDP is the result of an increase in value-added following output growth driven by a fall in the price of goods and services across the economy. Output growth involves five sources, including growth of exports, household consumption, government consumption, investment consumption, and intermediate demand for domestically-produced goods and services. Export growth is driven by a fall in export prices relative to world prices. The growth of other final demands comprising household consumption, government consumption, and investment consumption is driven by the fall in the price of domestically-produced goods and services across the economy. The growth of intermediate demand for domestically-produced goods and services is driven by a fall in the price of domestically-produced goods and services across the economy used as an input for production relative to import prices.

The economic impacts of railway investment measured in terms of growth of real GDP were small. This is attributable to the fact that the railway sector has become a relatively small sector in the Thai economy. Its output share accounts for 3.10 percent of total land transport. Its current (B.E. 2548) value-added contribution to GDP is 0.05 percent. Railway freight transport is a public enterprise that remains neglected in the eye of public policy. Only the passenger transport around the metropolitan cities has gained attention to become a modernized sector in seeking a solution to the growing congested city traffic. Only recently, in parallel with growing interest in the AEC, has intercity railway transport sought a means to benefit from the natural hub position of Thailand. The results produced by the CGE model suggest new investment in the railway sector works in order to regain a market share in land transport. Naturally, continued modernization can renew the railway sector as a principal mode of transportation.

Industry-specific Results

As shown in Figure 5, the contribution of rail transport investment is projected to canvas growth of the respective sector. In period T, a strong effect was found in railways, animal food, maize, industrial machinery, and plastic wares. The effect on basic rubber (latex) is projected to be the least growth. In period T+1, the growth of the animal food sector was the strongest, followed by maize, industrial machinery, railways, and plastic wares. The rubber products sector was affected the least.

A number of factors influence changes in the structure of the economy, which is characterized by unequal growth of the output of the respective sector. Rail investment reduces rail transport costs and prices, which reduces the cost of the goods and services of the respective sectors to a different degree, determined by the share of the rail transport costs of goods and services.

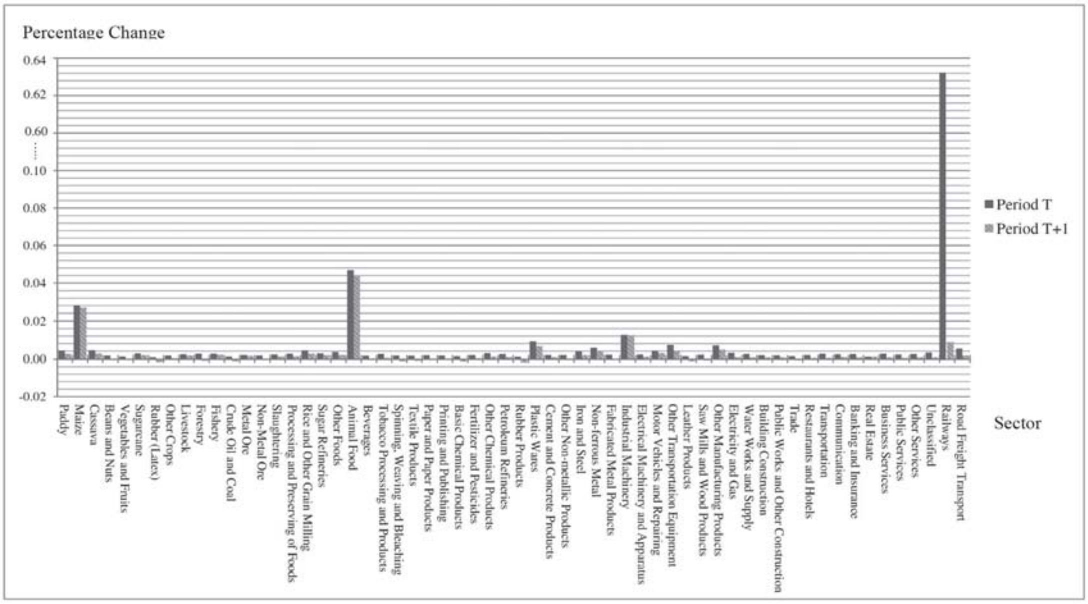

Figure 5: Percentage Change in Sectoral Outputs

Total Petroleum Consumption

Economic growth brought about by investment in rail transport naturally requires increased petroleum consumption, though the rate of increase is not necessarily proportionately the same. This is so as sectors differ in terms of growth rate and the proportion of petroleum consumption. Petroleum is used as an intermediate factor input in virtually all production. Sectors differ in terms of the proportion of petroleum input costs to total costs and in terms of growth rate. For these reasons, the petroleum consumption rate of the sector is not necessarily the same as the output growth rate. The CGE results expose these conditions.

Total economic growth naturally results in the growth of final demand, consisting of household consumption, investment consumption, and government consumption. This is so as spending is a function of income. Income growth is expected to produce an effect on the growth of consumption. Petroleum is used both for the intermediate input of production and for final consumption, largely for transportation fuel. A change in the final consumption of petroleum is projected by the CGE model.

In Table 2, the projection of real GDP and petroleum consumption is presented for period T and T+1. Energy efficiency can be evaluated as the ratio between the percentage change in total petroleum consumption and the percentage change in real GDP.

In period T, energy efficiency was evaluated as favorable with an elasticity value of 0.967085. However, energy efficiency deteriorated in period T+1, with the elasticity value 1.254111. In other study, Thailand's energy elasticity was found to be 1.04 (EPPO, 2013). The favorable efficiency in period T can be attributed to the negative growth of petroleum consumption for final demand, with the growth value -0.000231%. In period T+1, petroleum consumption for final demand regained significant positive growth, with the value 0.000619%. The unfavorable efficiency in period T+1 was largely attributable to petroleum consumption for final demand. In period T+1, the growth of petroleum consumption for intermediate use was less significant, with the computed value of the ratio between intermediate and total petroleum consumption declining from 1.711494 in period T to 1.170441 in period T+1. Rail investment was evaluated as stimulating efficient economic growth. However, the secondary effects delivered in period T+1 were the result of the distribution of investment in period T, which stimulated significant growth petroleum consumption for final demand.

Table 2: Percentage Change of Petroleum Consumption (Quantity)

Variable	Period T	Period T+1
Real GDP	0.002704	0.000669
Total Petroleum Consumption	0.002615	0.000839
Energy Elasticity = Total Petroleum Consumption / Real GDP	0.967085	1.254111
Intermediate	0.004467	0.000982
Final Demand	-0.000231	0.000619
Railway Sector	0.629198	0.008805
Road Freight Transport Sector	0.005468	0.001691
Land Transport	0.015197	0.001802
Ratio: Intermediate / Total Petroleum Consumption	1.711494	1.170441

Petroleum Savings

Rail transport investment is projected to induce a partial freight modal, shifting from road to rail as rail transport costs become more favorable relative to trucks. The decrease in total transport costs is attributable to the increased market share of more efficient rail transport.

The principal benefits of railway transport modernization include transport cost savings that help to reduce the cost and price of goods and services across the economy. Real economic growth is materialized through the improved competitiveness of Thai goods in both domestic and foreign markets. Transport cost savings through the improved efficiency of transportation is produced by fuel cost savings, which produces secondary benefits in terms of improving CO_2 emissions per ton of the transport of goods.

A modal shift in favor of road or a shift back to railway was suggested by the CGE model, which relies solely on the market price mechanism. Progress in road transport is favored by public investment in road networks, which continued for the entire period since the beginning of the development plan in B.E. 2504. This provides a climate for reduced road transport costs through time. On the other hand, the development plan without new investment railway stocks has been subject to depreciation through time.

As show in Table 3, based on the 2005 input-output table, the value of the output of railway accounted for 7,279.24 million Baht compared to 227,871.78 million Baht for road freight transport. Accordingly, the market share for railway and road freight transport was computed at 0.030956 and 0.969044 respectively (row [9] and [10]).

In period T, the output of the railway sector was projected by the CGE model to increase by 0.629198% (which amounted to 7,325.04 million Baht) compared to 0.005468% for road freight transport (which amounted to 227,884.24 million Baht). In period T+1, the output of the railway sector was projected to increase by 0.008805% (which amounted to 0.645 million Baht) compared to 0.001691% for road freight transport (which amounted to 3.854 million Baht) in period T+1.

Total market size was computed to increase from 1 to 1.000248 and 1.000267 in period T and T+1 respectively (Row [11]). The new market share for railway and road freight transport was computed at 0.031143 and 0.968857 respectively for period T

(Row [9] and [10]). In period T+1, the market share for railway and road freight transport was 0.031145 and 0.968855 respectively (Row [9] and [10]).

The contribution of the foregoing projections concerns the knowledge about the potential savings of transports cost and the magnitude of the shift of market share in favor of railway. Based on published data, one liter of fuel is used for a distance of 71 kilometers and 21 kilometers for rail and road freight transport respectively (ERIA, 2010). If road freight transport efficiency takes the value of 1, rail transport efficiency will be 3.38 (row [12] and [13]).

In order to evaluate total efficiency, the efficiency ratio of 3.38 for rail transport and 1 for road freight transport were applied to the market share in period 0, T, and T+1. New total market was obtained as the sum of the share of rail transport and road freight transport.

If the amount of freight to be transported for one Baht in period 0 takes the value 1.073703 after applying the efficiency ratio, the amount of freight to be transported for one Baht in period T will be 1.074149 and 1.074154 in period T+1 (row [16]). An increase in the amount of freight to be transported for one Baht means improved transport efficiency.

Table 3: Market Share and Cost Effectiveness of Land Transport

Variable	Computation	Original based on I-O Table	Period T	Period T+1
Output Value Based on I-O Table (thousand Baht)				
Railway	[1]	7,279,241		
Road Freight Transport	[2]	227,871,787		
Total Market	[3] = [1]+[2]	235,151,028		
CGE Projection for Output (Percentage Change)				
Railway	[4]		0.629198	0.008805
Road Freight Transport	[5]		0.005468	0.001691
Computed Change of Output (thousand Baht)				
Railway	[6]=[1]*(1+([4]/100))	7,279,241	7,325,042	7,325,687
Road Freight Transport	[7]=[2]*(1+([5]/100))	227,871,787	227,884,247	227,888,101
Total Market	[8]=[6]+[7]	235,151,028	235,209,289	235,213,787
Computed Market Share				
Railway	[9] = [6] / [8]	0.030956	0.031143	0.031145
Road Freight Transport	[10] = [7] / [8]	0.969044	0.968857	0.968855
Total Market	[11] = Change of [8]	1.000000	1.000248	1.000267
Parameter for Land Transport Efficiency [/1]				
Railway Efficiency Index	[12]	3.380952	3.380952	3.380952
Road Freight Transport Efficiency Index	[13]	1.000000	1.000000	1.000000
Applying Parameter to Market Share				
Railway	[14] = [9]*[12]	0.104659	0.105292	0.105299
Road Freight Transport	[15] = [10]*[13]	0.969044	0.968857	0.968855
Total	[16] = [14]+[15]	1.073703	1.074149	1.074154

Note: [/1] ERIA, 2010.

The evaluation of petroleum savings for land transport is shown in Table 4. A change in output was projected by the CGE model to be 0.629198% and 0.005468% for rail transport and road freight transport respectively in period T (row 1 and 2 in column [2]). The projection was 0.008805% and 0.001691% for rail transport and road freight transport respectively in period T+1 (row 1 and 2 in column [3]).

The value of output for period 0 was based on I-O Table, amounting to 7,279,241 thousand Baht and 227,871,787 thousand Baht for rail transport and road freight transport respectively (row 3 and 4). The total output of land transport was the sum of rail transport and road freight transport, amounting to 235,151,028 thousand Baht (row 5).

By applying the CGE projection of change, the value of output became 7,325,042 thousand Baht and 227,884,247 thousand Baht for rail transport and road freight transport respectively in period T (row 3 and 4 in column [2]). The value became 7,325,687 thousand Baht and 227,888,101 thousand Baht for rail transport and road freight transport respectively in period T+1 (row 3 and 4 in column [3]). Accordingly, the value of the total output of land transport became 235,209,289 thousand Baht and 235,213,787 thousand Baht in period T and T+1 respectively (row 5 in column [2] and [3]). The change in total output of land transport for period T and T+1 shown in row 6 was computed as [2] - [1] and [3] - [2]. The change of total land transport in percentage change form is shown in row 7.

The CGE projection of the change in petroleum consumption is presented in percentage change form in row 8. The petroleum savings for land transport expressed in percentage change form in row 9 is computed as row 7 - row 8. Rail investment was evaluated as contributing significantly to petroleum savings.

Table 4: Petroleum Saving of Land Transport

		Period 0 Based on I-O Table [1]	Computed Value for Period T [2]	Computed Value for Period T+1 [3]
1	CGE Projection of Change of Railway Output (%)		0.629198	0.008805
2	CGE Projection of Change of Road Freight Transport Output (%)		0.005468	0.001691
3	Output of Railway (thousand Baht)	7,279,241	7,325,042	7,325,687
4	Output of Road Freight Transport (thousand Baht)	227,871,787	227,884,247	227,888,101
5	Total Land Transport (thousand Baht)	235,151,028	235,209,289	235,213,787
6	Change of Total Land Transport (thousand Baht)		58,261	4,498
7	Change of Total Land Transport (%)		0.024776	0.001913
8	CGE Projection of Change of Petroleum Consumption (%)		0.015197	0.001802
9	Computed Petroleum Savings of Land Transport (%) = [7] - [8]		0.009579	0.000111

Carbon Emissions

CO_2 emissions are a product of economic growth, which involves the growth of the energy used according to intermediate and final demand. The computation of CO_2 emissions was achieved by applying the published emission factor to savings in petroleum consumption. The approach adopted in this study was to apply the CO_2 emission factor to the change in the savings of petroleum consumption produced by the CGE model. The quantity of CO_2 emissions was proportionate to the savings in petroleum consumption.

The parameter for CO_2 per liter of gasoline and diesel was 0.00232 metric tons and 0.00267 metric tons respectively (EPA, 2005; IPCC, 2006; and EPA, 2013).

The computation of CO_2 emission savings is presented in Table 6. The computation method is described as follows.

$$CO_2 emission = (Fuel_{gasoline} \times EF_{gasoline}) + (Fuel_{diesel} \times EF_{disel})$$

where:

$CO_2 emission$ = Carbon emission in metric ton
$EF_{gasoline}$ = Emission factor of gasoline (metric tons CO2 per liter)
EF_{diesel} = Emission factor of diesel (metric tons CO2 per liter)
$Fuel_{gasoline}$ = Gasoline consumed (liter)
$Fuel_{diesel}$ = Diesel consumed (liter)

The savings of CO_2 emissions was found to be 8,147 tCO_2 and 94 tCO_2 in period T and T+1 respectively. The savings of CO_2 emissions was coupled with the savings in energy produced by a shift in land transport. The shift in land transport was found to produce energy savings in the form of the ratio of the percentage change of energy to the percentage change of real economic growth. If the percentage change of energy was lower than the percentage change of real economic growth, it was interpreted as saving energy. Conversely, if the percentage change of energy was higher than the percentage change of real economic growth, it was interpreted as inefficient use of energy. This approach to energy savings was found to be 0.009579% and 0.000111% in period T and T+1 respectively. Rail investment was found to contribute to significant energy savings.

Table 5: Change in Carbon Dioxide Emissions: Use of Emission Factor

Description	Computation	Period T	Period T+1
Output of Petroleum Refinery (thousand Baht) (Based on I-O Table)	[1]	1,031,496,261	1,031,521,533
Petroleum Saving Computed from by CGE Model Projection (%)	[2]	0.00957	0.000111
Petroleum Saving Computed from by CGE Model Projection (thousand Baht)	[3]=[1]*([2]/100)	98,714	1,145
Petroleum Consumption Ratio /1			
Gasoline	[4]	0.29	0.29
Diesel	[5]	0.71	0.71
Petroleum Prices /1			
Gasoline (Baht/liter)	[6]	35.45	35.45
Diesel (Baht/liter)	[7]	29.83	29.83
Change in Petroleum Consumption			
Gasoline (liter)	[8]=([3]*[4]) / ([6]/1000)	807,535	9,367
Diesel (liter)	[9]=([3]*[5]) / ([7]/1000)	2,349,550	27,253
CO_2 Emission Factor /2			
Gasoline (tCO_2/liter)	[10]	0.00232	0.00232
Diesel (tCO_2/liter)	[11]	0.00267	0.00267
CO_2 Emission Change (tCO_2)	[12]=([8]*[10])+([9]*[11])	8,147	94

Note: /1 EPPO, 2013.
/2 EPA, 2005.

Conclusion

In this paper, the institutional context was given considerable weight to provide sufficient information on the background issues pertaining to the considerable time lag in the development of the railway sector and the reasons why the share of railway freight transport is suffering from a shrinkage.

Rail transport investment was evaluated in terms of economic and environmental impacts using a customized CGE model. At the aggregate level, economic impact was described according to the change in real GDP and other macro components. At the micro level, economic impact encompassed the range of changes in the components of the economic system, which were described as economic structural changes.

Environmental impacts were described narrowly in terms of CO_2 emissions couples with output changes. Change in output was coupled with petroleum use, which was translated into changes in CO_2 emissions.

Rail transport is allegedly considered more efficient compared to road transport. If rail investment creates a shift in freight transportation in favor of rail, the economic impacts are supposedly beneficial in terms of reduced transport costs, improved competitiveness, and positive economic growth. Further, if a shift in freight transportation in favor of rail occurs, improved energy efficiency will be materialized, which will be translated into favorable environmental performance.

The multisector equilibrium property of a CGE model offers a relevant complex evaluation of the economic impacts taking place across an economy. It is able to describe the transformation of the economy driven by differential changes in the cost and price of goods and services across the economy. The transformation of the economy is coupled by fuel use, which describes the changes in CO_2 emissions in the Thai economy.

The projection of a customized CGE model suggests that the economic growth impacts of rail investment is significantly positive. Rail transport investment increases the capital supply of the rail sector, decreases the costs and prices of rail transport, decreases the costs and prices of goods and services across the economy, improves export revenue, weakens import spending, and increases real GDP.

Economic impacts involve structural changes, which are driven by the differential growth of sectors. This differential growth of sectors is produced as rail transport investment favors sectors structurally.

In order to describe economic impacts, two-stage projections using a CGE model were adopted. The first stage introduced a surge in policy-induced rail investment for the Thai economy to produce a primary impact. The second stage introduced the distribution of endogenous investment across economic sectors, which was delivered by the first stage into the CGE system to produce secondary impacts.

It was found that rail transport investment produces 2 economic effects. First, it affects the reduced cost and price of rail transport as capital supply increases. The linkages of rail transport to other sectors help to reduce the cost and price of goods and services across the economy through linkages with each other.

Second, rail transport brings about improved fuel efficiency for the whole transport system as the share of rail transport increases. Improved fuel efficiency helps to improve the competitiveness of goods and services across the economy, improves export revenue, weakens the growth of import spending, and increases real GDP.

Environmental consequences were measured in terms of fuel efficiency and were associated with reduced CO_2 emissions per unit of output. The transportation system was transformed by the market in favor of rail, which offers improved fuel efficiency. In return, improved fuel efficiency reciprocated the rail investment with the reduced cost and price of goods and services, which drives growth of real GDP.

Policy Implications

The economic impact of rail investment was described as the positive growth of real GDP. The reduction in the cost and price of goods and services across the economy improves the competitiveness of domestically-produced goods and services compared to imported goods and services and results in a competitive position of exports in the world market. The longer-term benefit is industrial deepening, which increases the country's capacity in terms of self-reliance. Increased economic stability is achieved by industrial deepening and the degree of self-reliance. It is logical that the source of real GDP growth is the expansion of the output of goods and services, which finds improved opportunity both in domestic and world markets. The expansion of the output of goods and services is achieved as they become more competitive and as their cost is lowered due to the reduced cost of rail services derived from rail capital expansion.

A rail transportation system is typically a government establishment due to the sizable investment and the requirement of the expropriation of land for proper coordination of routes. It is the responsibility of public policy and rational for the implementation by a public enterprise. Further, there is the issue concerning the public enterprise that operates a monopoly business. The principle behind the establishment of a public enterprise is to maximize public welfare as opposed to profit maximization. In reality, an economy needs both private and public enterprises. According to the nature of the rail transport system, development and implementation require the role of public enterprises. In the context of a monopoly, the public enterprise needs to adopt a public welfare maximization policy—the public enterprise needs to be protected against misuse by private interests.

The comparative advantage of a rail transportation system is cheaper freight per unit of goods and services. Public policy is an important factor for the development of such a system. In the absence of clearly-determined public policy, the market tends to be biased in favor of road transport; the expansion of road transport involves relatively less capitalization capability.

Investments in rail transport infrastructure can result in a modal shift from a road to rail mode of land transport, which for technical reasons reduces the carbon dioxide emissions due to better energy efficiency. However, Thailand is a country in the Non-Annex group where the buying and selling of carbon credits occurs in the voluntary market. This mechanism works to reduce GHG emissions in the form of verified emission reductions, where the price is typically lower than the price for compliance market as certified emission reductions. The price might be distorted and not reflect the reality. This may be inherent as shadow price that may result is not enough incentive to reduce the carbon dioxide emissions.

Future Research

The evaluation of rail investment in Thailand produced by this study, using the CGE model, provides information about possible economic changes at a economy-wide level, which will be accompanied by changes in energy consumption and the release of pollution. In terms of the Pareto criterion, a smaller value of energy elasticity, that is, the ratio between the percentage change in energy and the percentage change in real GDP, is better. Potential environmental changes were projected by this study. An interesting issue to explore further, using the CGE model, would be the effect of more stringent environmental measures on the structure of transportation and the interplay between different modes of transport. More stringent environmental measures can be expected in the near future, as pressure is produced by growth-limiting factors, including the assimilative capacity of land, the hydrosphere, and the atmosphere. This type of study is set to ask how the economy can be arranged within environmental standards.

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