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Report

Optimising steel hub location in Thailand

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Abstract: The optimal location of a steel hub in Thailand was analysed by applying a specific research methodology designed to evaluate locations near the seaports. The growth of Thailand's steel industry has become a centre of attention in the last decade, resulting in substantial efforts to form a distribution service centre to minimise the logistic costs associated with handling large steel flows in the future. The main analysis of the steel hub location focused on areas situated near Laem Cha Bang, Map Ta Phut and Prachuab ports since these top three ports are considered important in terms of their steel throughput in Thailand. The transport costs associated with the shipment and inland transport together with port tariffs were calculated for the proposed scenarios of steel hub establishment and these were compared with the existing situation without steel hub. The findings showed that a steel hub located near Laem Cha Bang port was the optimal option involving a saving of 9.4% on the total system costs incurred under the existing situation.

Keywords: steel hub, steel industry, logistics, Laem Cha Bang seaport, Map Ta Phut seaport, Prachuab seaport

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INTRODUCTION

The expansion of iron and steel industries in Thailand has become a centre of attention in the last decade due to the fact that it provides materials for major industries in the construction, machinery, automobile and appliance sectors. The steel industry is a substantially competitive business in terms of price and quality, which has resulted in the Thai steel industry experiencing fluctuations in imported raw material prices, production quality and transport costs. Serious competition among contributors in the market regarding time, costs and product quality especially has produced inefficient logistics management and weak coordination among all units of the supply chain. The obvious competitive nature of contributors in the steel supply chain and the need to cut

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costs in transportation has led to the concept of forming a distribution service centre as a steel hub in Thailand with the aim of serving semi-finished and fabricated steel products to domestic steel producers and consumers at cheaper costs.

The aim of this paper is to assess the total cost benefits resulting from an alternative steel hub in Thailand—one that would primarily service the existing domestic end users. Therefore, the objectives are to model the incidence of steel flows entering Thailand and the alternative location of steel hub and to compare these with the existing condition (base case) in the evaluation process.

BACKGROUND INFORMATION

Integrated Steel Production Process

The steel production process is generally divided into four phases [1] as shown in Figure 1. In Phase 1, the iron ore procured from an ore mine is mixed with coke or natural gas and fed into a blast furnace to produce pig iron and hot metal whereas if the input is processed by direct smelting reduction, the result will be sponge iron. Pig iron, hot metal and sponge iron are the fundamental materials for the next phase of steelmaking and casting. In Phase 2, hot metal and pig iron are inserted into a basic oxygen furnace to produce liquid steel as part of the improvement process. Sponge iron and scrap can be fed into an electric arc furnace and converted into liquid steel. Then the steel liquid is sent for casting to generate billets, blooms and slabs, which are the basic components for all imported crude steel.

In Thailand, the steel producers provide steel at this stage of the process for steel forming in Phase 3 where the billets, blooms and slabs are manufactured using a hot forming process into hot-rolled products and they can be continuously transformed by cold-rolled forming to produce cold-rolled products. Further processing produces steel products such as long products (bar, wire and hot formed section) derived from billets and flat products (hot-rolled coil, hot-rolled plate and cold-rolled coil) derived from slabs [1]. The steel products in this phase can be value-added by fabrication with the processes of galvanisation by both hot-dip and electro methods, aluminisation, colour coating and tin plating. All the steel types produced in Phase 3 are delivered to end users in the construction, automotive and electronic sectors.

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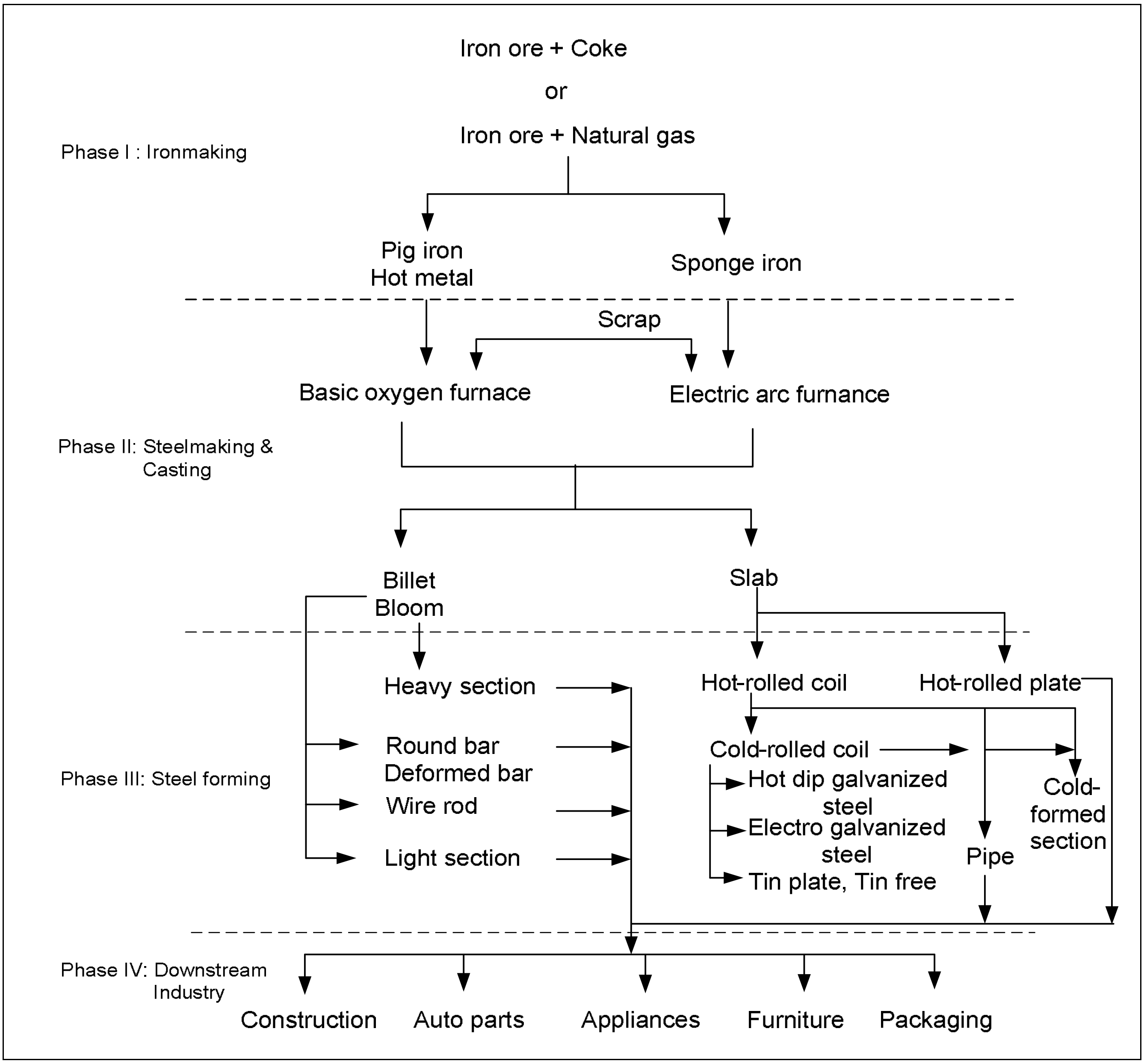

Figure 1. Integrated steel production process [2]

Overview of Global Patterns in Steel Production, Consumption and Trade

China has strengthened its position as the largest steel producing country in the world, increasing crude steel production (covering continuous casting and ingot casting processes) by 77.4% from 353.2 million ton in 2005 to 626.7 million ton in 2010. Crude steel production in Japan was the second highest in the world after China in 2010. It rose marginally from 116.2 to 120.2 million ton during 2005-2007 and gradually decreased to 109.6 million ton in 2010. Crude steel production in India in 2010 was 68.32 million ton, up 49.2% from 2005, making it the fourth largest steel producer in the world, ahead of South Korea whose crude steel production was 58.4 million ton in 2010, up 22.0% from 2005. In Thailand, over the same period, crude steel production decreased by 19.7% from 5.2 to 4.1 million ton. In other Asian countries, production in Taiwan was relatively unchanged from 18.9 slightly up to 19.7 million ton, while production in Malaysia slightly increased by 7.5% from 5.3 to 5.6 million ton and production in Indonesia was relatively

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unchanged during the same period. The top 10 steel producing countries and their steel consumption, exports and imports are shown in Figure 2. The top 10 steel producers dominated world steel production, accounting for 80.7% in 2010, whereas the top four major producers in Asia, i.e. China, Japan, India and South Korea produced 750.3 million ton of crude steel, amounting to 75.3% of the world's and 95.3% of Asia's total crude steel output in 2010. China alone accounted for 44.2% of total world steel and 72.8% of steel production in Asia in 2010.

On the steel consumption side, China was also the global leader in 2010 followed by USA and India. Figure 2 shows that in many countries, the level of production was roughly equal to the level of consumption [3]. Nonetheless, the notable exceptions are China, Japan, Russia and Ukraine which had substantially higher production than domestic consumption and this implies that they can export a considerable volume of their steel products. Japan and China were the top two exporting countries in the world, accounting for 42.7 and 41.6 million ton of semi-finished and finished steel products respectively, whilst jointly Russia and Ukraine exported 27.4 million ton of steel products. On the other hand, USA, South Korea and Germany relied on imports to substitute for their lack of domestic production capacity.

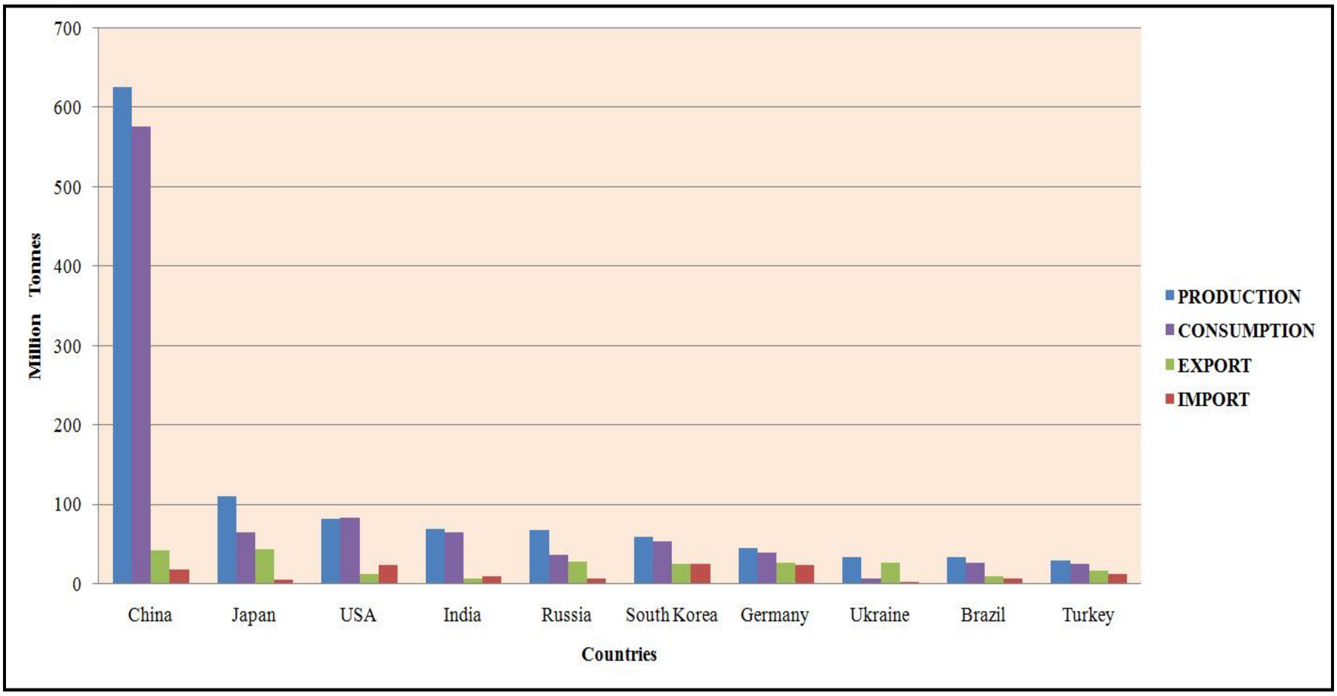

Figure 2. Top 10 crude steel producing countries and their steel consumption, imports and exports in 2010 [3]

Production, Imports, Exports and Consumption of Steel Products in Thailand

In 2010, steel supply chain in Thailand consumed about 14.0 million ton of steel products. Consumption during 2005-2010 ranged between 10.8-14.0 million ton. Production of hot-rolled products, the initial products that will be further processed into other products, however, gradually decreased from 14.4 million ton in 2005 to 11.1 million ton in 2010 with Thailand importing more than 12 million ton of iron and steel products in 2010 [3] (Figure 3). The majority of the imported steel products from Japan were those that could not be manufactured in Thailand such as the high-grade, hot-rolled products which were produced from pig iron and used in the automotive industry

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and electrical appliance parts. Thailand exports of semi-finished and finished steel products gradually decreased from 2.2 million ton in 2005 to 1.8 million ton in 2010 [3].

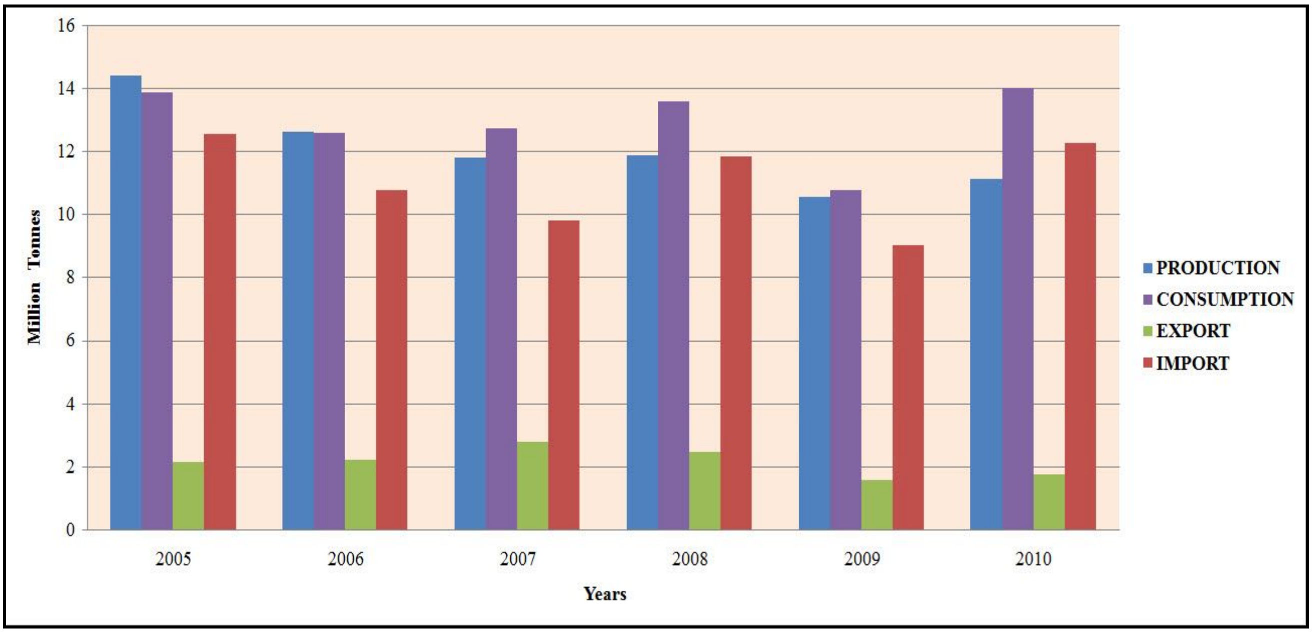

Figure 3. Steel production in Thailand, apparent steel import and export in 2005-2010 [3]

Steel Hub Model

In the steel logistics and distribution process, a steel hub is the intermediary which provides services between steel mills and end users. End users in the steel industry are the original equipment manufacturers (OEMs) that assemble finished products from parts, modules or components supplied by intermediaries in order to operate their own businesses such as construction and auto parts manufacturing. The intermediaries act as steel service centres, stockists and contract manufacturers as well as component suppliers. The Centre for Maritime Studies [4] classifies the steel distribution model into four types (Figure 4). The first type involves the steel mill supplying the crude or semi-finished steel directly to the OEM, who needs to manage its own stocks of steel. It will also process fabricated steel (coating, welding and drawing) and make steel into parts and components which will be used in its product assembly. In this case, the end user conducts the stockholding and processing functions on its own without utilising any functions of a steel hub.

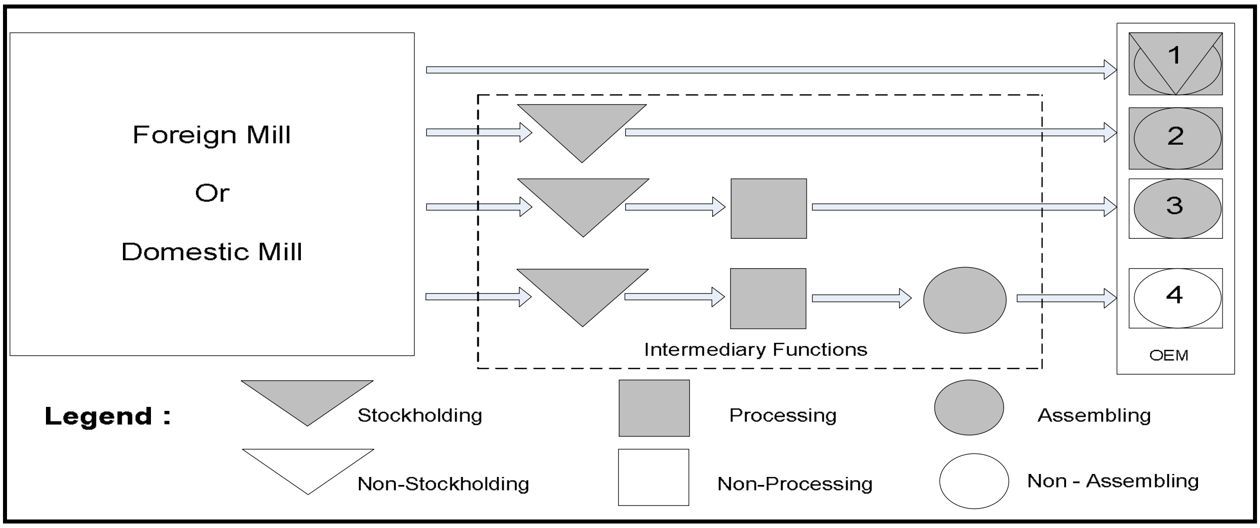

Figure 4. Steel production and distribution chain [4]

The second type of steel distribution takes the form of steel mill supplying steel to the OEM via the steel hub, which performs the functions of a steel stockist and supplies the steel to the end user. The end user purchases steel supplies in order to process them into parts and components for assembly into final products. The third type of steel distribution involves the steel mill supplying crude or semi-finished steel to the OEM via the two operations of stockholding and processing. The internal operation in the steel hub could involve a stockist who holds the stocks and sends them to a steel-processing centre. However, a steel service centre sometimes could handle both the stockholding and processing of the steel and then supplies the processed product to the end user, who still retains the assembly function in this model. Lastly, the steel hub could control the three main functions, namely stockholding, processing and assembling. The operating function in the steel hub would incorporate a stockist, processing centre and/or contract manufacturer, which then assembles the components for the OEM, who only needs to perform product testing or packaging and labelling of the assembled product. Alternatively, a steel service centre could undertake the functions of stockholding and processing and then deliver the processed steel components to a contract manufacturer to undertake the next step in the steel hub operation.

A successful steel distribution model in China provides a useful example [4]. Le Cong is a town situated in the Shunde district of Foshan city in China near the port of Nansha. In terms of steel distribution, Le Cong is the largest steel distribution centre in China; there are more than 1,600 steel distribution companies in Le Cong with about 10,000,000 ton of steel throughput handled per year. The steel in Le Cong is exported using mainly land transport. Le Cong uses open-air sites for the majority of its functions to sell the intermediate steel products such as steel rods and plates and focuses on value-added production by receiving crude steel from the mills and undertaking steel cutting and making steel parts in the mill for car manufactures. Furthermore, Le Cong has built up a strong base of knowledge and expertise in steel trading and distribution with the help of an electronic commerce (e-commerce) system. This facility can serve Le Cong as a one-stop steel trading centre for China in the future. The distribution model of the Le Cong hub is shown in Figure 5.

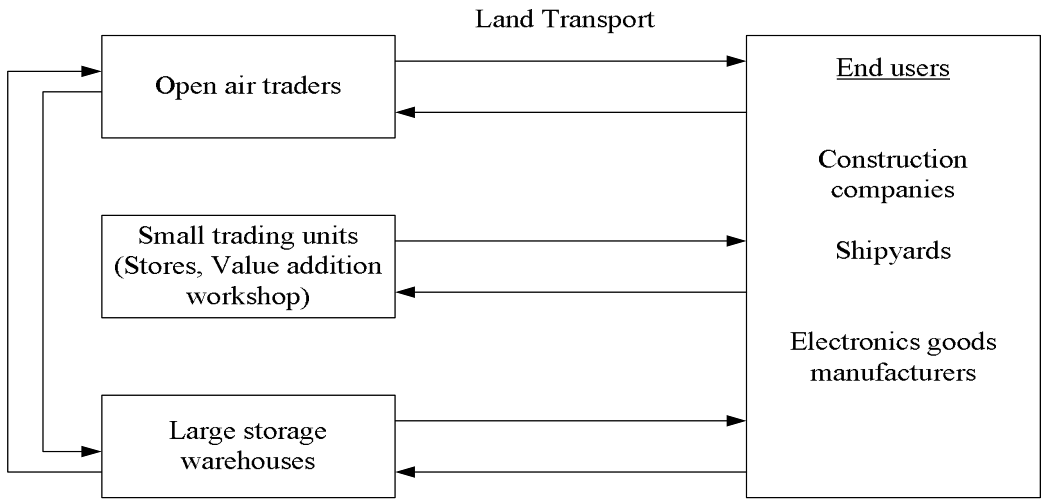

Figure 5. Steel Distribution Model of Le Cong Hub [4]

The steel hub basically contains three key operators: steel service centres (SSC), steel stockists and marketing parts. The Centre of Maritime Studies [4] defines SSC as an operation that buys finished steel, often processes it in some way and then sells it in a slightly different form. Technically, SSC distributes the steel and other metal products which have been processed from an original form into a more value-added form required by customers. Nonetheless, SSC is less capital-intensive than a steel mill as it does not need furnaces, casters and rolling mills. Stockists are not involved in the processing of base steel products but rather focus on ordinary stockholding of steel products and provide low or no value-added services. Stockists mainly operate under a break-bulk-consolidate principle at the regional and local levels and their key business is the timely delivery of products to the customers. Comparatively, SSC has high capabilities in value-adding processing services and breaking up bulk deliveries, whereas a stockist has core capabilities in stockholding and break-bulk deliveries. As part of its marketing services, it will facilitate steel trading between the manufacturers and the end users. The key business is to make strong connections with its traders.

ANALYSIS OF THE STEEL HUB MODEL IN THAILAND

The opportunities are considered for restructuring the current point-to-point routes of steel deliveries from both foreign and domestic production sources in Thailand to one based on a hub-and-spoke network centre. This involves the use of large vessels of around 35,000–50,000 dry weight metric ton (dwt) per shipment to handle the steel products and to reduce the cost of steel import through economies of scale. The initial analysis focuses on the ports with the greatest throughput of steel products. Statistics of steel throughput were gathered from the Marine and Customs Department for 9 alternative transhipment ports in Thailand (Figure 6). The top three customs checkpoints considered important in terms of steel throughput in 2008 were located at ports in Laem Chabang (LCB) consisting of the LCB port, Sri Racha Harbour and the Siam Seaport in Chon Buri (4.2 million ton), Map Ta Phut (MTP) port in Rayong (3.4 million ton) and Prachuab Port in Prachuab Khiri Khan (2.3 million ton). The top three custom checkpoints dominate annual steel facilitation and amount to almost 100% of the nation's throughput. The residual steel is distributed through Phuket (18,184 ton), Ranong (6,601 ton), Klong Yai, Trat (5,254 ton), Songkla (4,730 ton), Nakhon Si Thammarat (2,500 ton) and Satun (0.4 ton). The steel hub analysis pays specific attention to the top-three locations and investigated them in detail. To assess the alternative steel hub options in Thailand, four possible scenarios are considered:

1. Base case: the current situation
2. Scenario 1: steel hub is established around the LCB ports.
3. Scenario 2: steel hub is established around MTP port.
4. Scenario 3: steel hub is established around Prachuab port.

Figure 6. Locations of Thai steel handling ports

Only steel product flows (hot-forming and cold-forming products) which currently do not pass through the steel hub area are assumed to be transshipped at the steel hub in each scenario (but not for the base case). For instance, there are substantial volumes of steel products shipped to the ports around LCB, MTP and Prachuab ports. In the base case, all steel flows of both crude steel, semi-finished products and hot-forming and cold-forming products were transshipped in their current unloaded ports (that could be ports around the LCB, MTP and Prachuab ports which are the focused transhipment ports in this study) and forwarded to the steel customers. Scenario 1 assumed that all these flows are actually transshipped in ports around LCB and forwarded to the steel hub situated in the industrial zone around LCB, whereas any crude steel and semi-finished products shipped still remain at their transhipment ports (in all cases), since the conceptual operation of a steel hub does not include the steel producing process. This suggests that there is indeed potential for additional steel flow transhipments through the LCB ports, especially if there are cost savings to

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be gained. For a better understanding, the conceptual flow chart of the methodology is summarised in Figure 7.

The total cost shown in Figure 7 was derived from foreign sources of steel purchased by the steel producers and customers in Thailand and was calculated from the ocean shipping cost, port tariffs and inland transport costs. It makes use of cost, time and distance components. Therefore, it can be considered as a supply chain system problem to determine the minimum total cost of cargo movement along the supply chain, which is particularly significant in international trade. It has been accepted globally as a standard methodology for analysing supply chain effectiveness in a range of operational and commercial circumstances for general cargo [5-6]. Subsequently, the total costs of alternative steel hub locations and the base case were compared in order to find the optimal steel hub location. A number of studies in the last decade can be found [7-10]. The next section considers scenario modelling and cost analysis after the hub is established.

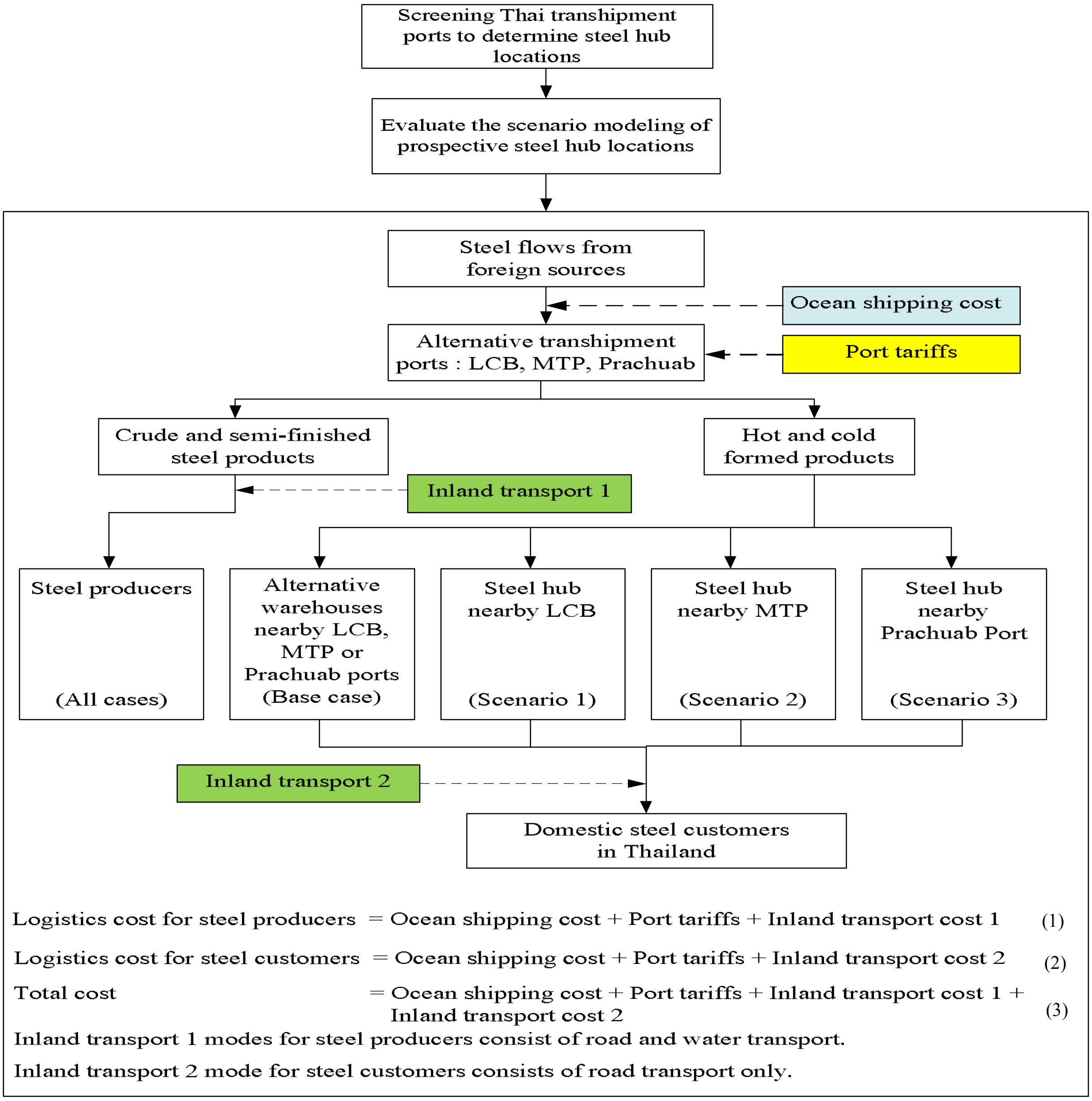

Figure 7. Conceptual flowchart of methodology

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MODELED COST ANALYSIS

Mainline Ship Deviation Distance

The initial task in the evaluation process was to determine the deviation distance from the original source of material from foreign countries to each prospective steel hub (Table 1). The estimation of the mainline ship deviation distance is important, although this forms just one part of the overall transhipment distance/cost-assessment process.

Table 1. Mainline ship deviation distance from steel trading countries to prospective steel hub [11]

Steel Trading Countries/Port Transhipment via	LCB	MTP	Prachuab
	Deviation distance (Nautical miles)		
Japan	2,914	2,871	2,891
China	2,202	2,158	2,179
Russia	10,390	10,354	10,335
Korea	2,491	2,448	2,469
Australia	4,560	4,522	4,506
Ukraine	7,042	7,005	6,986
Taiwan	1,624	1,581	1,602
India	3,203	3,167	3,147
Malaysia	980	943	924
USA	7,690	7,646	7,667
Vietnam	1020	977	998
Singapore	774	741	700
Indonesia	1,238	1,200	1,184
Philippines	1,403	1,360	1,381

The targeted destinations in this analysis were divided in two groups: the steel producers and the end users who consume the steel products from the hot-forming, cold-forming and fabricating processes operated by the steel producers. The crude steel and semi-finished steel amounts transported via the candidate transhipment ports before reaching their final destination at steel producers' mills are shown in Table 2. Since the functions of the steel hub do not require furnaces, casters and rolling mills, the flow direction and amount of crude steel and semi-finished products, such as pig iron, billets, slabs, bloom and ingots, are still shipped from foreign sources to their current destinations. This suggests that the establishment of a steel hub does not need to compete directly with the existing major steel producers in Thailand but does seek to facilitate the possibility of reducing costs, in particular those associated with transporting products to serve the end users. Although the location of a steel hub near the existing mills seems to be a good option for steel producers, the steel hub really performs a transition process from manufacturing to serving end user processes. This means that steel distribution from the hub to the end users also needs to be seriously taken into account. From an investigation of the imports by steel producers in Thailand carried out by the Transport Institute [2] and the results of conducting field interviews with the major steel producers, it can be concluded that the main steel producers are located in three provinces: Rayong, Samut Prakan and Prachuab Khiri Khan. The demand distribution of crude steel, semi-finished steel products and hot- and cold-formed products to steel producers were specified (Table 3). The results indicated that the main destination of steel import from the LCB transhipment ports was Samut Prakan (91%) with the mode of transport being 90% by ship and 10% by road. The destination of steel import from the MTP transhipment port was almost 90% to Rayong and the rest was delivered to Samut Prakan. For Prachuab port, the destination of steel import was 100% to Prachuab Khiri Khan. The demand distribution from the MTP and Prachuab transhipment ports was mostly by road. Although this part of the crude and semi-finished steel transportation process did not depend on the selection of steel hub location since this depends on the hot- and cold-formed products transportation instead, the results of different total costs between existing situation (base case) and other scenarios involved in the establishment of a steel hub are clearer if these costs are included.

Table 2. Steel quantities through custom check points [12]

Customs checkpoint	Crude steel and semi-finished steel products (ton)	Hot- and cold- formed products (ton)
LCB	2,937,463	2,354,528
MTP	2,354,398	1,887,171
Prachuab	1,598,688	1,281,431

Table 3. Steel imports by steel producers [2]

Location of steel producer	Transhipment port	Quantity (%)	Transport mode (%)	
			Ship	Road
Rayong	MTP	86	0	100
	Prachuab	14	0	100
Samut Prakan	LCB	91	90	10
	MTP	9	0	100
Prachuab Khiri Khan	Prachuab	100	0	100

Mainline Ship Deviation Cost plus Inland Transport

This cost analysis considered a 50,000 dwt ship to transport steel from various sources in 14 countries to the three transhipment ports that are nearby each of the candidate steel hubs. The mainline ship deviation costs can be considered using two approaches. The first approach establishes the actual freight rate for a number of steel products currently being quoted by the freight market. The second approach calculates the voyage cost based on the fundamental costs regarding vessels and time charts, which includes fuel expenses, to provide a better estimation of the underlying ship deviation cost structure. As the cost structure of the specified ship size was not available to include in the first approach, no market rates were available. Consequently, the second approach was used based on estimation of actual voyage costs.

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Baird [8] supported this second approach asserting that the value of a ship's time can be determined by the prevailing daily time or charter rate or, for owned ships, the daily ship capital and operating costs. Furthermore, time charter rates (dependent on the voyage distance and ship size) being more visible and more standard, provide for much greater clarity and scrutiny as appropriate and representative measures of ship provision costs. The shipping costs from 14 countries to the three transshipment ports were analysed based on the estimation of actual voyage costs regarding the distance and the specified ship size (Table 4).

Based on this approach, at this stage, the port tariffs for each port have not yet been included. Therefore, in order to give a full account of costs, the port tariffs at the three candidate transshipment points were investigated because they are one of the most important factors in the selection of the transshipment location [7, 13]. Table 5 presents port tariffs which consider the main items in this analysis—conservancy dues, berth hire and conventional cargo wharfage—for a 50,000 dwt ship entering port.

The next step in the process was to calculate the inland transport distance between each of the respective transshipment ports and the main locations of steel customers. The distances between the transshipment ports and the steel hubs were not taken into account in this analysis since the analysis assumes that the three hubs are located very close to their respective transhipment ports. Table 6 presents the distance to 22 end-user destinations and demand distribution of hot- and cold-formed products after the fabricating processes from the three prospective steel hubs. This analysis considered road transport, since the steel stockists mainly used road transport in the base case. The operating cost of a vehicle was $US 0.05692/ton.km which already included any product handling costs. The discounted transport cost from each steel hub to each demand point which was assumed as the hub point in each province of Thailand for receiving steel products from the steel hub was set at 0.9 leading to a realistic configuration that every link of the inland transport network carries large amounts of steel between hubs [14].

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Table 4. Mainline ship costs derived from steel trading countries to each prospective steel hub [15]

Steel trading country/Port transhipment via	LCB	MTP	Prachuab
	Steel shipping cost for 50,000 dwt ship (US$/ton)		
Japan	32.53	32.07	32.42
China	29.12	28.91	29.01
Russia	68.42	68.25	68.16
Korea	30.50	30.90	30.40
Australia	40.18	40.25	40.18
Ukraine	52.35	52.17	52.08
Taiwan	26.34	26.14	26.24
India	33.92	33.75	33.65
Malaysia	23.25	23.07	22.98
United States	55.46	55.25	55.35
Vietnam	23.44	23.24	23.34
Singapore	22.26	22.10	21.91
Indonesia	24.49	24.31	24.23
Philippines	25.28	25.08	25.18

Table 5. Port tariffs for a 50,000 dwt ship collected and developed from [16-18]

Steel trading countries/Port transhipment via	LCB	MTP	Prachuab
	Port tariff for a 50,000 dwt ship ($US)		
Conservancy dues	14,820	11,856	14,820
Berth hire	4,631	4,631	6,175
Conventional cargo wharfage	50,000	50,000	66,667

Table 6. Deviation distances and demand distribution from steel hubs to domestic destinations [2]

LCB	MTP	Prachuab	Destination	Demand distribution (%)
Distance from hub to destination (km)				
785	838	1020	Chiang Mai	2.06
151	203	329	Bangkok	26.98
379	427	500	Kanchanaburi	1.51
448	498	684	Kamphaeng Phet	0.77
426	456	747	Khon Kaen	3.14
114	145	485	Chachoengsao	2.01
28	84	446	Chon Buri	4.46
298	346	511	Chai Nat	2.1
191	239	319	Nakhon Pathom	1.46
364	413	621	Nakhon Ratchasima	4.72
352	406	572	Nakhon Sawan	3.83
143	199	513	Prachin Buri	2.01
472	522	714	Phitsanulok	3.75
66	12	535	Rayong	4.9
238	284	277	Ratchaburi	2.46
101	174	365	Samut Prakan	17.46
161	210	319	Samut Sakhon	8.28
210	259	470	Saraburi	2.1
218	267	435	Suphan Buri	0.62
764	813	285	Surat Thani	0.75
185	234	418	Ayutthaya	1.8
626	657	971	Ubon Ratchathani	2.87

RESULTS AND DISCUSSION

The enumeration method was applied to all variables. The model was composed of 14 foreign sources, 3 transhipment ports near which steel hubs were proposed to be established, 3 steel producers whose demand was crude and semi-finished steel products and 22 steel consumers whose demand was steel products fabricated from hot- and cold-formed steel products. Table 7 shows the logistics costs derived from Equation (1) in Figure 7 for the movement of the crude and semi-finished steel products through the three transhipment ports. The costs depended on the amount of steel moved through each port. Nonetheless, it can be observed that the LCB ports provide the minimum portion of ocean shipping and port tariffs (73.5% and 2.75% respectively) compared with MTP (91.58%; 3.3%) and Prachuab (92.03%; 4.35%). Furthermore, the inland transport costs by road and coastal transportation at the LCB ports were the highest components of the total system costs (23.73%) compared with MTP (5.13%) and Prachuab (3.62%) because no crude steel or semi-finished steel was forwarded to the main steel producers in Chon Buri. The main destinations of

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steel transshipped using the LCB ports were Samut Prakan and Rayong. The interview results from a representative steel producer in Chonburi revealed that generally they do not import steel by themselves but rather purchase the hot-formed products from the mills in Rayong.

Table 7. Logistics costs of moving crude steel and semi-finished steel products to steel producers (US$ million)

Cost component	Transhipment port			Total cost (US$ million)
	LCB (2.94 MMT)	**MTP (2.35 MMT)**	**Prachuab (1.6 MMT)**	
Steel foreign sources to port transhipment	109.20 (73.5%)	86.97 (91.58%)	59.21 (92.03%)	255.38 (82.96%)
Port tariffs	4.08 (2.75%)	3.13 (3.3%)	2.80 (4.35%)	10.01 (3.25%)
Inland transport	35.24 (23.73%)	4.87 (5.13%)	2.33 (3.62%)	42.44 (13.79%)
Total costs	**148.53**	**94.97**	**64.34**	**307.84**

MMT = Million metric ton

Table 8 shows the logistics costs for hot- and cold-formed steel products through the three transhipment ports derived from Equation (2) in Figure 7. It can be observed that Prachuab port provides the lowest portion of total system costs in ocean shipping (57.84%) compared with the MTP (69.68%) and the LCB (73.44%) ports. Tariffs made up about the same portion of costs for all three ports, with a range of 2.5–2.74%. Nevertheless, the LCB ports offered the cheapest cost portion for inland transport with 23.82% versus MTP at 27.81% and Prachuab port at 39.43%.

Table 8. Logistics costs of moving hot- and cold-formed steel products to steel consumers (US$ million)

	Transhipment port			Total cost (US$ million)
	LCB (2.35 MMT)	**MTP (1.89 MMT)**	**Prachuab (1.28 MMT)**	
Steel foreign sources to port transhipment	87.53 (73.44%)	69.71 (69.68%)	47.46 (57.84%)	204.7 (67.94%)
Port tariffs	3.27 (2.74%)	2.51 (2.51%)	2.25 (2.74%)	8.03 (2.67%)
Inland transport	28.39 (23.82%)	27.82 (27.81%)	32.36 (39.43%)	88.56 (29.39%)
Total costs	**119.19**	**100.04**	**82.06**	**301.29**

MMT = Million metric ton

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The total costs considered for deciding the optimal steel hub location focused on hot- and cold-formed steel products and the logistics cost derived from moving crude and semi-finished steel products for steel producers derived from Equation (3) in Figure 7. As a result (shown in Table 9), the LCB ports in Scenario 1 were selected as the optimal solution involving the establishment of a steel hub near the so-called LCB ports.

Table 9. Total costs (US$ million) of base case and three scenarios for a steel hub evaluation

Hot- and cold-formed steel products	**Base case**	**Scenario 1 LCB steel hub**	**Scenario 2 MTP steel hub**	**Scenario 3 Prachuab steel hub**
Steel origin sources to port transhipment	204.70 (67.49%)	205.33 (75.23%)	204.02 (71.67%)	204.56 (60.21%)
Port tariffs	8.03 (2.67%)	7.67 (2.81%)	7.34 (2.58%)	9.68 (2.85%)
Inland transport	88.56 (29.39%)	59.93 (21.96%)	73.28 (25.74%)	125.51 (36.94%)
Total costs	**301.29**	**272.93**	**284.64**	**339.75**

A number of interesting observations can be made from Table 9. Firstly, 75.23% of the total costs in Scenario 1 is related to ocean shipping costs derived from various sources to transhipment ports. This was the highest cost in every case, amounting to as much as US$ 205.33 million, which was slightly higher (0.31%) than the base case scenario of US$ 204.70 million. Secondly, the minimum cost for ocean shipping (US$ 204.02 million) was at the MTP steel hub (the steel hub located near the MTP port) in Scenario 2, which was slightly cheaper than the base case and Scenarios 1 and 3, by amounts of US$ 0.68 million, US$ 1.31 and US$ 0.54 million respectively. Thirdly, the most expensive port tariffs were at Prachuab steel hub (the steel hub located near Prachuab port) in Scenario 3, amounting to US$ 9.68 million (2.85% of total costs) whilst the cheapest port tariffs were at MTP (US$ 7.34 million, 2.58% of total costs). The inland transport costs for the LCB steel hub in scenario 1 were the cheapest compared to the values of US$ 88.56 million (29.39% of total costs), US$ 73.28 million (25.74% of total costs) and US$ 125.51 million (36.94% of total costs) for the base case, MTP and Prachuab steel hubs respectively. It can be observed that the parameter of inland transport costs for the LCB steel hub in Scenario 1 played a key role in the LCB steel hub achieving the optimal solution by providing the lowest total system costs of US$ 272.93 million, which represented a saving of US$ 28.36 million (9.41%) from the base case.

CONCLUSIONS

Compared with the reference base case and competing steel hub locations, the optimal steel hub location must offer the lowest total system costs involving a combination of mainline ocean shipping costs, port tariffs and inland transport costs. Based on these three measures, the LCB steel hub offered the optimal location with savings of almost 10% compared to the base case. It was shown that the transport costs (a combination of shipping and inland transport costs) dominated, accounting for 97.19% whilst port tariffs represented only 2.81% of total system costs. This explains the significance of the location at which steel imports are received for distribution to domestic markets.

Since the steel hub does not aim to compete with the major steel mills in Thailand, the steel hub function focuses on imported hot- and cold-formed steel products and fabrication for value-added processing to the imported steel before supplying it to the domestic market. Another possible function of a steel hub, not dealt with here, is import and re-export services for neighboring countries such as Laos, Vietnam and Cambodia or other countries where the cost penalty for transhipment via a steel hub and the economies of scale associated with using large ships are influential points to consider when comparing with direct shipment. Such an additional function requires the hub to be established in a “free zone” or “bonded zone” where, with the agreement of the Customs Department, the establishment costs for setting up the free zone hub mean that no tax is levied on the imported and re-exported steel products.

By assessing simultaneously the impact of shipping costs, port tariffs and inland transport costs on steel flows and using the information to determine the optimal steel hub location based on these parameters, this paper has applied a specific method for the analysis of a steel hub location in Thailand. These findings appear to fit well with the steel industry trend towards increased transhipment based on the development of a steel hub near the selected port. The establishment of a steel hub offers a substantial reduction in inland transport costs, thereby resulting in minimisation of the overall transport costs. Nonetheless, further improvements to the steel hub system should consider increasing the facilities of the selected loading port servicing the hub so that larger ships can be handled to accommodate the structural shifts of increased trade flow to enhance service efficiencies and generate further reductions in overall transport costs.

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