

Thailand's Kra Canal: economic feasibility and expert perspectives on its complexity

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Abstract

Purpose – Asia is one of the most important economic regions of the world. The Kra Canal is considered as a potential maritime transportation node in global trade. Indeed, for centuries, a canal across the Kra isthmus in Thailand has been proposed as holding significant economic and logistical benefits through goods transfer and exchange, yet it remains unconstructed. Common tools in feasibility studies are PESTELE and SWOT analyses, which incorporate cost-benefit and value analyses. The purpose of this paper is to assess the feasibility of the Kra Canal using approaches to complement existing studies.

Design/methodology/approach – In this paper, we combine quantitative and qualitative methodologies to holistically assess the feasibility of the Kra Canal. Quantitatively, we consider the economic feasibility of the canal using Net Present Value to evaluate its potential financial benefits. Qualitatively, we then present expert perspectives gathered from in-depth interviews with field experts ($n = 20$) to identify key aspects of complexity related to the economic, political and overall feasibility of the canal.

Findings – We discuss the possibility of the canal's construction and describe possible future impacts the canal could have on the region geopolitically, for example, in its role in China's One Belt One Road initiative and also in how Singapore and Tanjung Pelapas in Malaysia might react. Ultimately, we find significant complexities with the Kra Canal project, ones which anyone contemplating its construction would, we argue, be wise to consider.

Originality/value – This paper combined qualitative and quantitative methods to explore the economic, political and overall feasibility of the Kra Canal. The methodologies and findings supplement past relevant studies and help evaluate the economic, political and overall feasibility of the Kra Canal's investment project. This is particularly timely considering its potential ability as a route given recent geopolitical events and, for example, as part of China's Belt and Road initiative and its ability to reduce carbon and sulphur emissions.

Keywords Kra Canal, Ship, Feasibility, Shipping

Paper type Research paper

1. Introduction

The Kra Canal would constitute a huge significant maritime project since it would be located on a key maritime transportation node in the Asia region. This canal [as with any transiting canal (Abdul Rahman *et al.*, 2016; Zis, 2024)] might change sailing voyages and schedules by shortening the sailing time, distance and other potential economic activities. Moreover, considering the canal as a route is particularly timely considering its potential ability as a route given recent geopolitical events and, for example, as part of China's Belt and Road initiative, and its ability to reduce carbon and sulphur emissions (Zis, 2024). Nevertheless, this project is still under the evaluation stage due to complex consideration factors (e.g. economic benefit,

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engineering technique, investor intention, political relations, homeland security, stakeholders' concern and geopolitical implications to name but a few). This paper draws on quantitative and qualitative approaches to first quantitatively consider the financial feasibility of the Kra Canal using Net Present Value (NPV) and then qualitatively present and analyse the perspectives of a number of field experts ($N = 20$) to identify key aspects of complexity involved with building the canal. It contributes to the literature by providing an NPV economic analysis of the canal, identifying the complexities involved with building the canal through the field expert data and discussing these two forms of empirical data in the context of potential geopolitical impacts and ramifications involved with its construction.

Notably, and for centuries, canals have been key to shipping; the Suez and Panama Canals dramatically cut distances and catalysed technology (Fletcher, 1958; Waltham, 2020; Zis, 2024), and the Kra Canal (and also Nicaragua and Caspian Sea Canal) has also been considered for similar reasons. Figure 1 shows the location of the Kra Canal across the Kra Isthmus in Thailand.

Previous Kra Canal studies focused on the theoretical geopolitical implications of the canal (e.g. Er, 2018), sometimes for specific countries [e.g. Vietnam (Manh Cuong and Hung, 2020)] and on the specific reduction of sailing distances (e.g. Rahman *et al.*, 2016). Such studies consider the canal from a particular focus or country. In the strategic management fields, analytical tools commonly used to assess project viability are SWOT (Strengths, Weaknesses, Opportunities, Threats) and PESTELE (Political, Economic, Social, Technological, Environmental, Legal and Ethical) analyses (Tseng and Pilcher, 2022a). Notably, initial quantitative analyses suggest that the canal has important benefits (Er, 2018). Such data and analyses help identify whether to construct the canal (Huebner, 1915;



Figure 1.
Location of the
Kra Canal

Source(s): Abdul Rahman *et al.* (2016)

Gibbs, 1978; Mostafa, 2004; Nusantara, 2005; De Marucci, 2012; Ungo and Sabonge, 2012; Yip and Wong, 2015; Chen *et al.*, 2016, 2019; Chu *et al.*, 2017; McCall and Taylor, 2018; Cahan, 2019).

The Kra Canal is a large-scale infrastructure project and needs to be carefully assessed by feasibility analysis to fit the construction target of being able to carry large vessels (Zis, 2024) and sustainability. Such analyses need to include aspects such as construction cost, maintenance cost, external social costs (e.g. air emissions, ecological impact), economic and financial benefit, technique, policy and politics. From the perspective of shipping operators, they might be concerned about economic benefits since it can save voyage costs (e.g. human resources and fuel costs) by reducing sailing routes. Regarding Thailand's authorities, the Kra Canal might bring toll revenue and a significant number of jobs for local residents and economic development in Southern Thailand. For Chinese authorities, this canal provides an alternative route to reduce transport costs from the petroleum exporter countries in the East Asian region and reduce the reliance on overland pipelines and the Malacca Strait from the perspective of economic and strategic benefit. It is therefore a key pillar in China's One-Belt One Road initiative. In sum, such a huge transportation infrastructure is expected to bring trade benefits through shorter shipping routes and increase the attractiveness of many investors. Furthermore, given its shortening of sailing distances, it will allow for reductions in carbon and sulphur emissions to help meet new IMO targets (cf. Zis, 2024). Nevertheless, this canal is not without potential controversy or potential adverse impacts. For example, it also might result in Muslim-Buddhist conflicts since the canal will create a physical separation of Thailand's territory (Er, 2018). This is an issue with many fatalities, with at least 6,000 dead and over 10,000 injured in low-intensity conflict between Muslim insurgents and the Thai military and police in the early 20th century (Er, 2018). This national social instability arguably also needs to be considered before constructing the Kra Canal. Also, other social externalities (e.g. negative environment and ecological impact) should be considered when constructing this canal. Furthermore, the geopolitical impacts of the canal could have significant impacts given its potential role in China's Maritime Silk Road. The canal could provide an instantly reduced link for China to transport goods and trade with Europe cutting out traditional routes through key hubs such as Singapore. Such a move could be far-reaching in impact.

The concept of the Kra Canal was first presented in the early 1600s. This canal can not be formally invested due to many complex factors. Economic concern (e.g. ratio of investment) is an important barrier. Tseng and Pilcher (2022a) have explored the opportunities and challenges of the Kra Canal and offered route feasibility from a strategic analysis perspective (including SWOT and PESTLE) and also in terms of the canal's decarbonising and emissions reduction potential (Tseng and Pilcher, 2022b). Based on the research findings of Tseng and Pilcher (2022a, b), we further adopted combined analysis methodologies with quantitative and qualitative methods to explore the economic, political and overall feasibility of the Kra Canal and researched who stands to gain and lose from its construction. Such an analysis approach is new in Kra Canal studies and can present prospective insights for the stakeholders (e.g. shipping operators, government and port authorities, finance, insurance, etc.). Further, we first review the literature on the Kra Canal's history and opportunities. Second, we then detail our methods for arriving at and gathering empirical data: economic analysis using NPV to evaluate the potential financial benefits of the Kra Canal and our approach to interviewing field experts, our thematic analysis and reliability and validity in these in-depth interviews. We then present and discuss our results from both the NPV and the interviewee perspectives. These results consider the economic feasibility of the canal from several scenarios, whether the Kra Canal will be built, and the challenges, impacts and benefits involved. We discuss the data in the context of potential geopolitical impacts and ramifications of building the canal. In the conclusion, we summarise the key points and complexities and suggest areas for future studies.

2. The Kra Canal: history, opportunities and feasibility

A proposed canal across the Kra isthmus in Thailand, with significant economic and logistical benefits of reduced sailing times, distances and fuel consumption on East-West shipping routes, is centuries old. The canal was first mooted in 1677 (Min, 2015; Rahman *et al.*, 2016). In the 1980s, a Japanese-led consortium proposed a sea-level canal across the isthmus, but due to possible regional political impacts, this never materialised (Sulong, 2012). Later, in the 1990s, Thai authorities supported the canal for its potentially significant economic boost following the late 1990s Asian Financial crisis (Sulong, 2012). Again, nothing materialised, this time over concerns regarding the huge cost (Sulong, 2012). In the 2000s, the canal was again considered but again never materialised, possibly due to internal political conflicts in Thailand (Sulong, 2012). Indeed, internal Thai politics are said to present issues, particularly in relation to its Maritime Silk Road initiative: “Beijing cannot simply impose its infrastructural preferences on Bangkok without the latter’s consent” (Er, 2018, p. 1). This is something the Thai government may need to accede to [perhaps similarly to the Nicaragua government (see below)] but it currently appears reluctant to do so. Indeed, recently, the Thai government has mooted a possible rail cross-link rather than a canal (Maritime Executive, 2020).

Regarding its opportunities, some estimate the Kra Canal to save approximately 27 h and 1337.5 km of sailing distances (Rahman *et al.*, 2016; Yuan *et al.*, 2020; Freight Forwarder, 2021), and others to save 2–3 days (Lam, 2018). However, it is argued that the saving time might be shorter if the ship’s sailing time in the canal is considered. For example, as shown in Figure 2, traditional Asia–India subcontinent for West and Eastbound shipping routes pass around Singapore. The revised westbound route is Shanghai–Ningbo–Sejkou–Kra Canal–Karachi. The revised eastbound route is Nundra–Mundra–Kra Canal–Hong Kong–Shanghai. Singapore and Port Klang will be bypassed when the Kra Canal is adopted. Arguably, however, Singapore and other ports affected would counter with measures designed to encourage shipping to use their port facilities, in a similar way to how the Panama Canal was expanded and the Suez Canal was then expanded to allow for two-way traffic. In short, it is perfectly feasible to expect one geopolitical ramification to involve a reaction from those affected by the introduction of the canal.

In the literature, canals are said to be of increasing importance in reducing transiting times and emissions (Zis, 2024), and with the Kra Canal, many argue that the canal would

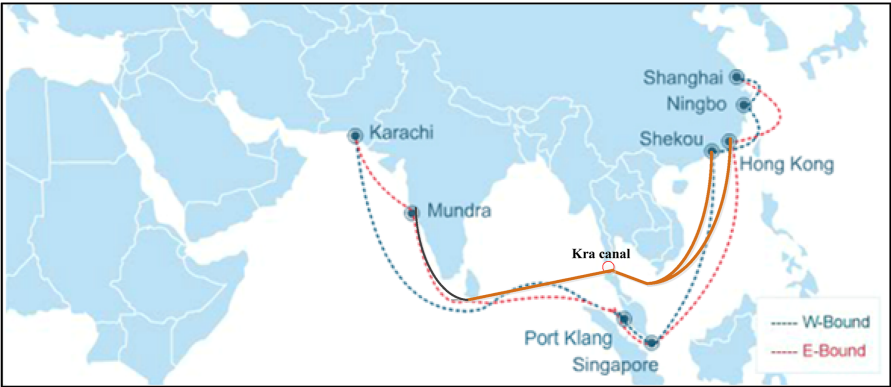


Figure 2.
Asia–India
subcontinent
shipping route

Source(s): Revised by authors (original shipping map is cited from Yang Ming Marine Transport Corp.) https://www.yangming.com/service/service_network/routemap.aspx

reduce emissions and find it would benefit Tanker shipping when the tanker market was volatile (Heng and Yip, 2018). Other studies found that the canal would greatly benefit hub and feeder ports, particularly with China's One Belt One Road initiative (Zeng *et al.*, 2018). The route also avoids the Malacca Straits (Lau and Lee, 2016), which are becoming increasingly congested [with an estimated 70,000–80,000 vessels passing annually (Rhoden, 2015; Heng and Yip, 2018)] and constitute a piracy threat (Axbard, 2016). Some even describe it as the “oriental Panama Canal” (Zeng *et al.*, 2018). Regardless of whether the canal involves fewer benefits regarding emissions, it would if electric trailers or trains pulled ships, and it has clear economic potential in reducing ship daily costs, and operational costs and avoiding the increasing congestion in the Malacca Straits.

However, many challenges to building the canal exist. One is the huge cost involved, as Thailand would find it unfeasible to afford the canal, yet may not wish to accede control or benefits to others. In 1999, Japan's Global Infrastructure Fund estimated a 50 Km canal at 20–28 billion US dollars minimum (Thongsin, 2002; Billington, 2011; Rahman *et al.*, 2016; Freight Forwarder, 2021). Technically, the canal also presents challenges. Some propose it to be approximately 102 km long (almost double the previous Japanese estimate of 50 km), 400 m wide, and 25 m in depth; large enough for any vessel, including ultra-large crude carriers with a 300,000 deadweight tonnage (Rahman *et al.*, 2016; Heng and Yip, 2018). Political challenges are its possible impact on relations in ASEAN, especially if it negatively impacts the ports of Singapore and Klang due to their being bypassed. Geopolitically, a possible challenge is the canal's strengthening China's regional control of trade, giving it greater power over the United States (Er, 2018). Environmentally also, the canal would adversely impact the area it is built in (Freight Forwarder, 2021). With any canal, shipping companies will inevitably assess whether the toll cost means the canal is more expensive than sailing a toll-free distance (Zis, 2024). Nevertheless, with increased environmental awareness and emission reductions coming to the fore (IMO, 2020), it is arguable that canals anywhere will become increasingly important.

Regarding analytical tools, PESTEL analyses have focused on the canal's impact on Malaysia (Rahman *et al.*, 2016). SWOT analyses can also help formulate specific business strategies and have been applied to port energy (Christodoulou and Cullinane, 2019), ship safety (Miroslav *et al.*, 2015) and maritime policy (Celik and Kandakoglu, 2012). Both tools help frame and guide any research along a particular route or direction, and we have used them ourselves in relation to the Kra Canal (Tseng and Pilcher, 2022a). Here we complement and expand the existing literature base by using NPV to consider the economic feasibility of the canal and simultaneously present and discuss the perspectives of a number of field experts ($n = 20$) on the complexities involved in the construction of the Kra Canal. This creates empirical data for us to then discuss the potential geopolitical ramifications of the canal, which we do in the final section of this paper. Below we first describe why we adopted NPV and also, in more detail, our approach to interviewing the field experts. Following this, we first present the results of the NPV, and then the perspectives of the field experts before discussing the feasibility of the canal, the complexities involved in building it, and also the potential geopolitical ramifications of the canal, such as possible future reactions to its construction from, say, the port of Singapore.

3. Methods

Regarding quantitative economic analysis, we adopt NPV to evaluate the financial benefit of Kra Canal. NPV has been widely used in project evaluation and similar fields in the past, such as BOT projects (Nguyen *et al.*, 2020), and cash flows of projects (Peymankar *et al.*, 2021). With regard to the qualitative gathering of the perspectives of the field experts, our approach reflected a grounded theory type study (Charmaz and Belgrave, 2007) and was broadly qualitative in method of investigation; and in thematic analysis (Braun and Clarke, 2006). We

gathered data from international experts in government and shipping operators in areas either a part of ASEAN (Singapore and Thailand) or with a strong (and arguably vested) interest in the Kra Canal (China and Taiwan). Although this strong interest meant these experts would have knowledge of the canal, it also meant the existence of subjectivity and bias (Guba and Lincoln, 2005). Notably, interviewing experts from other geographical regions would have a different view on any potential canal project and, while still inevitably biased, may be more objective and biased differently. Nevertheless, in attempts to redress any bias, all interviews were anonymous (Christians, 2011) and transcribed and analysed only by the authors (Bird, 2005). We also note that for future research, it would be beneficial to the field to interview experts from other geographical regions. We outlined this to interviewees at the outset of the interview, and later sent them transcripts, thereby increasing validity (Liamputtong, 2010). We interviewed almost equal numbers of government officials (9) and shipping operators (11) and an appropriate range of interviewees in different positions and roles in order to reduce sampling bias (Winship and Mare, 1992) via online. Experts averaged 18 years of experience for those working in China (from 16 to 25); 20 years for those working in Singapore (from 16 to 25); 17 in Thailand (from 10 to 21); and 20 in Taiwan (from 16 to 23). Table 1 provides more details about the participants and their areas of expertise and knowledge.

Interviews took place from March to April 2021 and were as comfortable and relaxed as possible to ensure free discussion and thereby aid the validity (in a qualitative sense) of the data. They were conducted privately in a location of the interviewee's choice (Powney and Watts, 1987), in the language interviewees were comfortable with, recorded on a secure device and were translated this was done by checking between the authors, one a native speaker in the source language and one a native speaker in the target language. Interviews averaged 22 min in length (ranging from 15 to 30) and were transcribed verbatim, and questions were focused on aspects such as the challenges involved in building the canal and its benefits. We now present and discuss these results.

4. Results

Results are presented and discussed as follows: Section 4.1 presents the results from the quantitative NPV analysis. Section 4.2 presents the sensitivity analysis. Section 5.2 presents the qualitative interview data from the perspectives of the field experts. As noted above, we adopted a grounded theory-type analysis that was also thematic in its nature. Consequently, the key themes that emerged for us from this data related to whether the canal itself will ever be built, and what the challenges are requirements for this to happen are. Further, what might be the potential impacts politically, environmentally and financially, and also which stakeholders stand gaining and lose from the canal. These were the main themes that emerged to us and provided a clear picture to us when discussed alongside the NPV findings (see Section 5) of the main issues involved with the possibility of a Kra Canal being built. Our sections for presenting the interview data are thus as follows: Section 4.3.1 considers whether the Kra Canal will be built; Section 4.3.2 presents the requirements and challenges; Section 4.3.3 presents political, environmental and financial impacts; and Section 4.3.4 describes who stands to gain and to lose. Complexities are highlighted throughout, and in the final discussion and conclusion section, these are considered alongside the results of the NPV analysis and possible future developments once the canal has been built.

4.1 NPV scenarios and analysis

The NPV is the sum of the present values of benefits and costs cash flows over some time. When the result of NPV is positive, it means the Kra Canal is worth investing in. On the other

Expert	Currently based in	Work in shipping	Position	Areas of knowledge, experience and expertise
1	China	17 years	Port Division Director Government Official	Port construction, investment, shipping/port development strategies/research. Handling container terminals, bulk containers, shipping schedules, intermodal transport/port logistics
2	China	25 years	Captain – major Shipping Company	Sailing experience of over 15 years, now handling shipping business, crew management/assignments, health and safety policy, ship maintenance, costing and management
3	China	16 years	Marine Department Government official	Shipping trade, import/export cargo flow between Asia/Europe/America and worldwide. Handles ship and port operation safety, sailing/berthing times and planning
4	China	17 years	Manager and Operator - major Shipping Company	Sailing scheduling/routing, tariff analysis, shipping market information analysis, port competitiveness and financial investment. Worked in Thailand for 5 years familiar with Kra Canal
5	China	16 years	Port Engineer – major Shipping Company	Port infrastructure development, management of equipment, shipping safety evaluation and implementation. Fleet maintenance and condition
6	Singapore	25 years	Maritime/Port Authority Division Director	Shipping environment, shipping industry development, port/terminal operations, port/shipping sustainability. Kra Canal research and potential impact on Singapore
7	Singapore	20 years	Maritime/Port Authority Division Director	Pilot training, international sailing conventions and rules. Shipping company advisor about safety evaluation, terminal operations and costings
8	Singapore	18 years	Maritime/Port Authority Official and Pilot	Pilot operations, port facilities, navigation procedures, competitiveness between Kra Canal and Straits of Malacca (e.g. Port of Singapore, Klang port)
9	Singapore	16 years	Manager - major Shipping Company	Shipping risk (political, financial) evaluation, government policy/trade, shipping transshipment, performance, route analysis, professional advice to government, shipping/insurance companies
10	Singapore	21 years	Manager - major Shipping Company	Port evaluation/selection/competitiveness. Shipping schedules/costs (e.g. slot hire, inland haulage bunkering, insurance, canal tolls) fleet allocation, port infrastructure/management

(continued)

Table 1.
Interview participants' experience and knowledge

Expert	Currently based in	Work in shipping	Position	Areas of knowledge, experience and expertise
11	Thailand	10 years	Senior Manager – Major Shipping Company	Port/Shipping logistics, marketing, strategic alliances, third and fourth party logistics, China’s One-Belt-One Road initiative and its impact (including Kra Canal evaluation) on various regions
12	Thailand	14 years	Senior Logistics Engineer – major Shipping Company	Maritime logistics distribution systems, collaboration with maritime supply chain partners. Port evaluation in the Thai context/impact of Kra Canal on the Asian shipping market
13	Thailand	20 years	Port logistics Engineer – major Shipping Company	Role of Kra Canal in China’s One Belt One Road policy – its impact on shipping and port economic development for Thailand and elsewhere (China, Singapore, Vietnam, Malaysia, India, Sri Lanka)
14	Thailand	18 years	Operator in a major Shipping company	Import/export customer (e.g. shipper, forwarder, etc.) service. Shipping marketing strategies. Kra Canal’s impact on the Europe–Asia shipping market
15	Thailand	21 years	Division Director – Government official	Shipping/port development in Thailand (e.g. of Bangkok and Laem Chabang ports), waterway transportation issues in Thailand, and Kra Canal investment project
16	Taiwan	23 years	Senior manager (captain) – major Shipping Company	Fleet sailing schedules (especially in Asia), ship characteristics, cost analysis, investment in the Kra Canal, and its impact on the global shipping market
17	Taiwan	21 years	Captain – major Shipping company	Shipping networks/canal toll (e.g. Suez, Panama) operations/shipping cost analysis (e.g. fuel cost estimates, crew costs, ship chartering, maintenance, insurance)
18	Taiwan	21 years	Maritime Port Bureau Division director – Government official	Port investment, port safety, port operation and management, crew training
19	Taiwan	17 years	Int. Ports Corporation Division Director – Government official	Port operation and management (international maritime conventions, green ports, port safety), global maritime development trends (including Suez, Panama and Kra Canals) highly published author
20	Taiwan	16 years	Maritime Port Bureau Division Director – Government official	International Maritime trends, port navigation, port operator training, key maritime research topics (including the impact of Kra Canal on the shipping market)

Table 1. Source(s): Created by P.H. Tseng

hand, if the result of NPV is negative, the project of the Kra Canal should be rejected. NPV can be calculated by following the time-discrete equation:

$$NPV = \sum_{j=1}^n NCF \times (1 + r)^{-j}$$

where n is the number of periods; NCF is net cash flow (revenue-cost) at moment j ; and r is the discount rate.

Kra Canal construction will cost 28bn US dollars (Rahman *et al.*, 2016; Freight Forwarder, 2021). Due to the cost contents of canal construction and maintenance being complex, we assume that the maintenance cost includes depreciation of fixed assets and employees' wages since they are the main two components of Kra cost estimation. We assume that the lifetime of the Kra Canal is 50 years. We assume these ships are container ships with laden, based on the toll calculation method of the Suez Canal Authority. We first calculate the toll fee calculation of these ships passing through the Suez Canal. Then, we re-calculate the toll fees of these ships passing the Kra Canal based on the sailing length difference between the Suez Canal and the Kra Canal [1]. The length of the Suez Canal is 193 km. The length of the Kra Canal is 102 km. We assume that the toll fee has a direct ratio with the canal length.

Since the ship sizes of various types of ships are complex, we assume three scenarios to understand the Kra Canal's benefit condition. Scenario 1: 100,000 container ships (all 40,000 net tonnages, laden, 7 lay). Scenario 2: 95,000 container ships (all 50,000 net tonnages, laden, 7 lay). Scenario 3: 90,000 container ships (all 60,000 net tonnages, laden, 7 lay).

Based on the toll of the Suez Canal Authority [2] in 2024, one container ship for 40,000 net tonnages, 50,000 net tonnages and 60,000 net tonnages will be charged 523,075 US dollars, 608,247 US dollars and 693,420 US dollars, respectively. Three scenarios are described as follows.

In Scenario 1

In the Suez Canal, one container ship (laden) with 40,000 net tonnage (7 lay) is charged 523,075 US dollars. In the Kra Canal, one container ship with 40,000 net tonnage (7 lay) will be charged 276,443 (=523,075*(102/193)). Toll revenue will be 27.64 billion US dollars (=276,443*100,000 US dollars) when 100,000 container ships pass the Kra Canal annually.

In scenario 2

In the Suez Canal, one container ship (laden) with 50,000 net tonnage (7 lay) is charged 608,247 US dollars. In the Kra Canal, one container ship with 50,000 net tonnage (7 lay) will be charged 321,457 (=608,247*(102/193)). Toll revenue will be 30.54 billion US dollars (=321,457*95,000 US dollars) when 95,000 container ships pass the Kra Canal annually.

In scenario 3

In the Suez Canal, one container ship (laden) with 60,000 net tonnages (7 lay) is charged 693,420 US dollars. In the Kra Canal, one container ship with 60,000 net tonnages (7 lay) will be charged 366,471 (=693,420*(102/193)). Toll revenue will be 32.98bn US dollars (=366,471*90,000 US dollars) when 90,000 container ships pass the Kra Canal annually.

Based on the rule of NPV, if the revenue is higher than the cost (e.g. construction and maintenance cost), the Kra Canal project should be invested in as it would add financial value to the Kra Canal.

Regarding the cost of the Kra Canal, assuming that it includes construction cost (28bn US dollars) and maintenance cost (e.g. depreciation of fixed assets, employees' wages) during the operation period (50 years).

We assume that the depreciation cost of fixed assets is 2.8bn US dollars (=28*10%) and employees' wages every year are 6 million US dollars annually. The cost is 30.86 (=28 + 2.8+0.06) billion US dollars. The interest rate of the bank is 1% and the lifetime is

50 years [3], respectively. The results of NPV in Scenarios 1 and 2 are negative and the results of NVP in Scenario 3 are positive, as shown in Table 2. The calculation of Scenario 1 can be found in Appendix.

In sum, as the above NPV economic calculations show, when a minimum of 90,000 container ships (laden, 7 lay) use the Kra Canal annually, it might obtain positive revenue under Scenario 3. Otherwise, by considering the revenue it could generate itself, i.e. by not subsuming or absorbing its costs in a wider initiative such as the One Belt One Road initiative, the Kra Canal might face serious operation losses.

4.2 Sensitivity analysis

Based on Scenario 3, sensitivity analysis is used to determine the results of important variables in this paper. Here we assume that the lifetime of the Kra Canal is between 100 and 200 years and the interest rate is between 2% and 4%, respectively. The results show that the maximum value of NPV is 103.98bn US dollars under the lifetime is 200 years and the interest rate is 2%. The minimum value of NPV is 51.95bn US dollars under the lifetime is 100 years and the interest rate is 4%, as shown in Table 3.

In sum, in this paper, scenario variables (e.g. the number of ships, toll fee of Kra Canal, construction cost of Kra Canal, depreciation fee of Kra Canal) might change in the future depending on many un-predicting factors (e.g. international trade situation, construction technique and costs, exchange rate, etc.). We now present the data we gathered from our interviews with field experts to complement this economic analysis.

4.3 Results of qualitative interviews

4.3.1 Will the Kra Canal be built?. Only 3 of the 20 experts felt the canal would be built. This was regardless of where they were based (one from China, Singapore and Thailand), although no one from Taiwan felt the canal would be built. Even those who thought it feasible were only mildly confident, for example, saying “I think it will be, but I do not know the time yet”. About half said “maybe” and occasionally gave answers equating to “no”, for example, “Not sure. Maybe it will be discussed for a long time and cannot achieve a final end in the future” (Taiwan). Comparatively, another expert felt that “I heard Nicaragua canal . . . always still is discussed. Maybe Kra Canal will be . . . similar . . . we do not know when it will be built” (Singapore). One expert felt the canal would not be constructed due to internal

Table 2.
Results of NPV
calculation

Scenario	Revenue (billion US dollars)	Cost (billion US dollars)	Number of ships	NPV (billion US dollars)
1	27.64	30.86	1,000,000	−58.11
2	30.54	30.86	95,000	−12.54
3	32.98	30.86	90,000	83.10

Source(s): Created by P.H. Tseng

Table 3.
Results of sensitivity
analysis (unit: billion
US dollars)

Sensitivity analysis	The interest rate is 2%	The interest rate is 3%	The interest rate is 4%
Lifetime is 100 years	91.37	66.99	51.95
Lifetime is 150 years	100.56	69.83	52.85
Lifetime is 200 years	103.98	70.48	52.98

Source(s): Created by P.H. Tseng

problems, saying *“The interior problems still exist in Thailand . . . I do not know when it will be constructed”* (Thailand). Another felt the canal would be built if barriers were overcome, saying *“If the key barriers (e.g. budget, technique) are overcome, I think true construction date is not too far”* (China). Perhaps summing up the general perspective of many, one expert commented that *“Many emperors in Thailand cannot construct this canal in the past. Maybe one day it will. Now, I do not know”* (Taiwan).

4.3.2 Requirements and challenges. Requirements and challenges can be broadly categorised as financial, technical and political. Financially, challenges were both to ensure sufficient finance and that tolls and costings were appropriate. The money required was up to US\$30bn according to many experts. There were political challenges connected with financing, as this expert noted: *“If Thailand cannot pay . . . [and] . . . will face financial loss when constructing the canal. Although China would like to invest in it, Thailand is concerned this canal will be controlled by China in the future”* (Singapore). Regarding fees, these could be for tolls or documents and bookings. For example, this expert noted that, *“besides toll fee, also includes booking fee, delay fee, document fee, etc.”* (Thailand). As with requirements for finance, technical requirements could be for construction; or afterward. For construction, this was often that the *“construction technique of [the] canal”* (Singapore) must be appropriate in terms of safety and environmental rules. One expert gave much detail, noting that the canal needed to flow straight, deep, avoid landslides and be supported by shipping networks: *“These problems must be effectively evaluated by various . . . experts (e.g. engineering, economy, safety, environment, etc.)”* (Thailand). Technical issues post-construction were many; as this expert noted: *“ensuring sailing feasibility . . . emergency response abilities . . . also . . . good hinterland transportation system for the port near the canal . . . road . . . and rail transport”* (China). Possibly waiting for future technical developments was also noted by one expert, who said, *“construction time problems is trouble. Someone say the current construction technique will take a long time . . . maybe adopting advanced techniques in the future is a solution”* (Singapore). One expert felt technical issues were associated with environmental issues, and a political issue of ensuring stability in the South of Thailand, saying *“environmental issues . . . [and the] race management problem in the South of Thailand”* (Taiwan) were key. Politically, both globally and internationally, it was considered essential that everyone agreed on plans. As succinctly conveyed by this expert: *“The attitude of Singapore [is key] since this canal might affect the shipping volume of Strait of Malacca. China will involve the companies of Thailand in . . . the construction and maintenance . . . the US government also plays a key role to allocate their military and strategic planning in this area”* (Thailand).

4.3.3 Financial, environmental and political impacts. The above data showed that regardless of the area experts were from, perspectives were similar. However, perspectives differed regarding potential financial, environmental and political impacts. Regarding financial impacts, experts from China saw these as “short term risk for longer-term gain”, for example, that, *“If the canal is constructed successfully, it will bring the industries development nearby. The return on investment will effectively be back soon”*. Singapore experts in contrast focused on technical financial details, for example establishing grace periods with lenders or financial minutiae. These were often highly detailed, for example, that *“managing the canal will involve many fees, such as tug services, transit reservation fee, pilotage, transiting vessel inspection service, security charges for transit vessels, tolls, etc.”*. In contrast, experts from Thailand focused on Thai government borrowing, one commenting, *“it is estimated the Kra Canal will cost about 30 billion US dollars. This involves the issue of how much money the Thailand government can ask for”*. By comparison, the Taiwan perspective focused on the political implications of investment, for example, that *“the construction fee is huge, I heard that China would like to invest in the Kra Canal, but Thailand worries that China might control the key decision power”*.

Regarding environmental impacts, there were again differences. Experts from China had a wide-ranging focus, for example, saying that the impacts would be on “*local residents, operators, wild animals, air quality, water, soil (ground), and garbage*”. Experts from China differed from experts from Taiwan (see immediately below) by suggesting that the Thai government may need excellent management abilities to follow rules: “*if everyone could follow related rules during construction and operation period, it might bring less environmental impacts. This is related to the management abilities of Thailand’s government*”. Taiwan’s experts’ perspective was that such rules controlled any impact, for example, one saying despite environmental impacts “*under the regulation of rules, the canal could still be constructed*”. By comparison, the Singapore expert perspective noted impacts on workers: “*particularly, many workers get injured or lose their life during the canal construction*”. Similarly but subtly different, Thai experts focused on social environmental impacts, one commenting “*from social impact perspectives, canal operations will bring serious damage for human beings. If operations result in water pollution this will affect the value of tourism . . . [and] . . . long term . . . heavy metal and oil pollution stays in the river bottom and thereby forms secondary pollution sources*”.

Politically, experts from China felt the canal may negatively impact on ASEAN, for example, that “*Singapore and Malaysia port will be directly affected . . . some of their volumes will transfer to Kra Canal . . . [and] . . . the revenues of these two countries will be reduced*”. The canal was felt to impact Thailand positively if all went well; however, “*if it exposes negative impacts in construction processes and future maintenance, it will bring harmful impacts for the Thai government*”. Perhaps surprisingly, Singapore experts mostly felt that the canal would have little impact, partly because Singapore’s port facilities were improving. As one noted, “*currently, the Singapore port authorities will construct new terminals . . . the service function and content will be strengthened . . . [so] . . . the impact of Kra Canal might be limited*”. Regarding impacts on ASEAN, Singapore experts highlighted the positive opportunity of cooperation, one commenting that it “*might be they will cooperate in the future*”. Also, some experts from Taiwan felt that building the canal represented a real opportunity for cooperation between ASEAN: “*countries in South East Asia might participate in investment and construction of the Kra Canal*”. Similar to those from China, Singapore experts said the canal could be positive or negative for Thailand and any investors depending on its success, one saying, “*if the economic development is not good, it will destroy relationships between countries who participate in the Kra Canal*”. Conversely, Thai experts expressed concerns about neighbouring countries’ reactions to the canal, for example, “*Thailand will worry about the animosity from neighbouring countries*”. Another commented similarly that “*other countries also worry that Thailand or other countries may use this canal for military purposes . . . thereby creating safety issues*”. Regarding wider political impacts, Thai experts said this depended on who built the canal, for example, one saying “*if Thailand control the Kra Canal . . . it can enhance their political position; but if China is too much involved . . . China may influence important decisions for the canal in the future*”. Experts from Taiwan felt that many were possible, such as that the canal could strengthen Thailand’s, may mean the US is affected or could help China.

4.3.4 *Gains and losses.* Experts’ comments on what would gain or lose from the canal were linked to a. the canal’s success and b. who invested in it. Regarding a. comments were similar to this expert’s: “*Currently, we do not know if the Kra Canal will be successful, so I do not know who will win*” (Taiwan). Also, this expert said, “*Maybe we will know . . . long-term*” (Thailand). In relation to b. comments were similar to this expert: “*countries that invest in the Kra Canal for the Thai government might get benefits*” (Singapore). Alternatively, “*if the canal is developed well, countries that participate . . . will get the benefits*” (Thailand). Mostly though, comments were simply, “*I do not know the answer now*” (Thailand) and “*currently, I do not know which countries will get the benefits*” (China)

or “it is difficult to identify . . . at this moment” (Singapore). Concomitantly, there were similar answers regarding who would lose, for example, “it is difficult to predict . . .” (Singapore) or “I do not know this yet” (Thai). Regarding whether the benefits were worthwhile, notably, the inability of the canal to provide similar reductions as the Suez or Panama Canal was highlighted, for example, “compared to Panama Suez Canal, the shortened route is limited” (Singapore). Insightfully, one expert from Taiwan observed that “In the past, someone might jokingly say the Kra Canal is the ‘Oriental Panama canal’. Actually, it cannot be compared . . . as the Panama canal can save 8,200 miles . . . and the Kra Canal only . . . 1,200 mile”. Also, some experts commented on specific conditions, such as when oil prices were high: “when the oil price is high, this canal will bring value, but if the operation scale or benefit is not significant, this will reduce the interest of shipping operator or investors” (Singapore). The value of benefits was considered dependent on hinterland development, for example: “depends on the development relationship between the Kra Canal and nearby ports, if they cooperate well . . . maybe it will bring positive effects” (China). It would also depend on ships actually using the Kra Canal, for example: “if most shipping operators do not use the Kra Canal, it will lose its attractiveness and then cannot show its value and effectiveness” (China). The canal’s capacity was key, for example: “the estimated depth and width of the canal is not very good . . . [organizations must] . . . conduct comprehensive planning when constructing this canal” (Thai). Shipping volume and throughput were indeed vital, for example: “it will cost 30 billion US dollars to construct, but might take 100 years to recoup the money . . . under only a limited volume” (Taiwan).

5. Discussion and conclusions

Many maritime practitioners and researchers have been concerned about the Kra Canal project since it might change Asian, even global maritime transportation nodes, resource allocation, and in addition, affect potential economic benefits and trade activities. This is particularly timely considering its potential ability as a route given recent geopolitical events and, for example, as part of China’s Belt and Road initiative. This paper combines quantitative and qualitative approaches to explore key issues when evaluating this canal. The evaluation factors consider toll revenue, construction cost (28bn US dollars) and maintenance cost (depreciation of fixed assets and employees’ wages). The above quantitative NPV calculations show potential scenarios (a minimum of 90,000 container ships (laden, 7 lay) using the Kra Canal annually) that can make Kra Canal’s obtain profitability in itself. The values of these scenario variables (e.g. number of container ships, laden, number of lay, types of ships, etc.) used in this paper might change as time goes on. Actually, it is quite difficult to attract 90,000 ships to pass the Kra Canal in the early operation period. Thus, the Kra Canal Authority might face liabilities for many years. It is argued that no one knows when Kra Canal can achieve a break-even situation from a financial perspective. Also, other potential evaluation variables (e.g. various types of ships) and methodologies (e.g. risk matrix) could be further used in future research. What is more, the above interview data show that there are significant complexities involved in building the canal, both environmental and political but also financial. In financial terms, precisely who funds the canal, under what terms the loans and repayments are drawn up, and who then actually “owns” the canal is a key issue. Moreover, as the above qualitative interview data show, Singapore might not be much affected by any Kra Canal, possibly because the level of sea traffic will have increased so much that the Kra Canal affords a pressure release and in fact exists to allow greater numbers of ships to move from Asia to Europe (and vice versa) as opposed to initiating any real shift in the route that traffic takes.

If geopolitical considerations are raised, geopolitically, it is clearly the case that China would arguably stand to gain the most from the construction of the Kra Canal. China’s One

Belt and One Road initiative aims to develop a Maritime Silk Road to link Chinese ports and other ports from China through Central Asia to Europe and Africa. The Kra Canal brings a new (or additional) trading route and links many potential business opportunities and attracts other countries to develop/invest in their ports near the Kra Canal and further to be an important port transshipment centre. From the Kra Canal's long-term insight perspective, China might continuously invest in ports in Southern Thailand and link their current Chinese ports (e.g. Hong Kong, Shanghai) and form shipping hub services for the rapid development of the Indian-Pacific Ocean region. Also, China's western region is expected to benefit through the investment/building of the Kra Canal and its hinterland connections and infrastructure. Regardless of whether the Kra Canal affords a shift in route or whether it simply allows for a greater volume of traffic on the Asia/Europe route, this will undoubtedly lead to the development of China and regional port infrastructure and clustering.

Based on the One Belt One Road initiative from China, the Asian Infrastructure Investment Bank [4] can finance loans for Asian countries that hope to invest in infrastructure facilities and improve the collaboration between Asian countries. Based on World Bank data [5], Thailand's GDP growth rate was -2% in 2022. Thus, the Thai authorities might not have enough funds to invest in the Kra Canal by themselves. External financial support (e.g. Asian Infrastructure Investment Bank) can offer a solution to Thailand's fund shortage problem at the beginning of the Kra Canal construction. Yet, there would then remain the key questions of ownership of the canal, and whether Thailand should sign away ownership of the canal to China to ensure the finances for its construction (in the same way the Nicaraguan government did for the yet-to-be-constructed Nicaragua canal).

Thus, the Kra Canal would be successful from a revenue perspective because its profits would be considered in light of its wider-reaching advantages for China's One Belt One Road initiative. In this context, the canal would arguably not need to be successful in itself but could be considered a "loss leader" in the view of its medium-term geopolitical gains for China. Nevertheless, this, in turn, leads to inevitable and complex questions of who funds the canal project, who owns it and who subsidises it if it makes a loss (whether China or Thailand or perhaps ASEAN nations as a whole).

At the same time, there is a danger that geopolitically the canal may create tensions in the ASEAN region and further afield. In the region itself, however, these tensions may be only hypothetical: it needs to be borne in mind that Singapore Port has continuously constructed mega port projects and has increased its service quality and efficiency [6]. It is argued that the number of ship transshipments from Singapore Port to Kra Canal would be very limited when the Kra Canal really starts to open. Singapore port has developed many advantages extremely well (e.g. service capability and efficiency, maritime-related industries cluster, etc.) and the Kra Canal retains many uncertainties which means it is difficult to replace Singapore port's role under limited distance reduction situations. Any decision relating to building the canal also needs to balance these possibilities against the immense cost and risk involved in building the canal. Yet, if the finance were coming from China, and it was considered to be a geopolitical move to construct the canal as part of a larger One Belt One Road initiative and the Maritime Silk Road, then maybe China would absorb many of the costs, in a similar way to which the US military stepped in to build the Panama Canal after the failure to do so by the construction company that built the Suez Canal, led by Ferdinand de Lesseps.

There are also national issues to consider in any construction project, most notably the ongoing conflict between Muslim separatists in the South of Thailand with the Thai military and police (Er, 2018). Any physical division of the country could arguably be used as rationale and justification by such separatists for dividing Thailand and creating a breakaway territory to the South that was closer to Malaysia. This is particularly key given Malaysia's increasing turn towards Islam and Muslim religious practices (Osman, 2017)

Regarding environmental aspects, the construction period might bring environmental pollution, such as noise, air emissions from explosions, truck transportation, hydrology damage, etc. However, when the Kra Canal is finished, it is expected that these environmental problems will be reduced. During the Kra Canal operation period, emission pollution from ships might be a concern. Based on Tseng and Pilcher (2022b), using a 7000 TEU containership, the Kra Canal cannot bring emission benefits due to the limited reduction of sailing distance. However, these emissions can be further mitigated by introducing clean energy into ships during ship sailing in the canal. From the long-term perspective, most ships will be more environmentally friendly due to the gradual strict environmental rules announced and implemented by the International Maritime Organization and also Thai regulations and laws. Thus, environmental problems from the canal and ship should not be a serious issue and certainly not as serious as proved to be the case with the Nicaragua canal, possibly the key factor in its not being built.

Three suggestions are provided for future research directions. First, to formulate an optimal toll fee-charging mechanism, cost and revenue analysis for Kra Canal with various types of ships (e.g. passenger ships, Ro/Ro ships, vehicle ships, LNG carriers, chemical and other liquid bulk carriers, container ships and general cargo ships) can be further investigated since it will affect the shipping cost estimation of shipping route and adoption intention of Kra Canal. For containerships, it can compare the operation cost (US\$) per TEU between adoption or non-adopting Kra Canal under shipping route evaluation and then figure out a suitable threshold of containership size. Second, to explore the range of potential funding scenarios for building the canal alongside the terms and conditions of ownership. Third, to further explore the geopolitical implications of building the canal from the perspectives of other ASEAN governments and from the perspectives of other stakeholders elsewhere in the world.

Notes

1. The toll fee of the canal might consider the vessel type, size and other transit characteristics (e.g. service capacity, user's demand) and this fee basis was formulated by the canal authority. Since the Kra Canal has not been built yet and the tariff of the Kra Canal toll is not easy to assume. Therefore, we adopt user's pay principle to calculate toll fees for Kra canal and the fee is charged by sailing length due to the longer sailing distance needing more human and facilities costs.
2. Suez Canal Authority. <https://www.suezcanal.gov.eg/English/Pages/default.aspx>
3. Sensitivity analysis is calculated by various values of interest rates and lifetime in Section 4.2.
4. https://bankwatch.org/aiib?gclid=Cj0KCQjwkruVBhCHARIsACVliOxSccJ5PzhUZCXAkQrFZRE DkKMf7vmKfuRoiq1c3gjvPRCSTj68Rb4aAj5oEALw_wcb
5. <https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations=TH>
6. Ship Technology. <https://www.ship-technology.com/features/size-matters-inside-tuas-mega-port-project-singapore/>

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Appendix

The calculation process of Scenario 1

Revenue is 27.64 billion US dollars annually.

Cost = 30.86 billion US Dollars (= 28 billion US Dollars (construction cost) + 2.8 billion US dollars (depreciation fee) + 6 million US dollars (employees' wages);

The interest rate of the Bank is 1% and the lifetime is 50 years, respectively.

Net Present Value (NPV) =

$$= \sum_{j=1}^{50} (27.64 - 30.86) \times (1.01)^{-j}$$

$$= -6.4 \times (\text{Present value, 1\%, 50}) \text{ (refer to compound interest table (present value, 1\%, 20))} = 39.196$$

$$= -3.22 \times 18.046$$

$$= -58.11 \text{ (billion US dollars) (reject to invest)}$$

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