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Paper 328

Proposed High-Speed Rail Line between Cairo-Alexandria: Cost-Benefit Analysis

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Abstract

Egypt National Railway trains (passenger and freight) are currently operated with diesel traction, except for two electrified metro lines in Cairo of about 60 km in length. The study of the opportunities for high-speed railways (HSR) in developing and emerging countries has approved funding of 1.65 billion euros to build the Cairo-Alexandria HSR line in Egypt. The HSR system could have a number of operational and environmental benefits. HSR is a break-through technology that allows trains running at speeds over 200 km/h. The most controversial part of the HSR investment is whether its cost could be compensated by the social benefits. The evaluation of different types of costs and benefits included a sequence of analytical steps. The results show that the project has a positive net present value (NPV) up to 45.18 million euros and achieves only about 11.66 percent internal rate of return. However, applying a broader cost benefit analysis to include all sources of benefit shows that it is highly desirable on an economic basis. Although extreme difficulty was experienced to obtain the required data and information, plausible and coherent results were achieved, which are also seen to be consistent with other results of HSR in Europe.

Keywords: high-speed rail, cost–benefit analysis, net present value, Egypt.

1 Introduction

In early 2013, there were more than 20,700 kilometers of new HSR lines in operation around the world and about 14,600 kilometers under construction to high speed services [1]. HSR is a brand new rail technology developed in the 20th century, which consists of a special infrastructure that allows trains running at a speed over 250 km/h. For medium distances (within 500 kilometers), HSR provides much competitive advantages over other transportation modes, i.e. conventional railway, roadway and air transport [2]. The study of the opportunities for HSR in developing and emerging countries has approved a funding of €1.65 billion to build HSR line connect Cairo-Alexandria in Egypt [3].

Investing in HSR is a significant social decision. The major consideration of HSR is its high capital cost, requiring to build the high speed infrastructure at a cost substantially higher than the conventional railway. The infrastructure maintenance cost of HSR is comparable with those of the conventional railway, but its building costs and the acquisition, operation and maintenance costs of specific rolling stock make it as an expensive option [4]. However, the public decision makers should not only focus on the financial costs, but the potential impacts on the community arising from the project as well [5]. Especially, the major challenge is how to ensure the social benefits gained from HSR are high enough to cover its construction, operating costs. The aim of this paper is concerned with examining the financial and economic viability of proposed HSR Cairo-Alexandria railway line. In addition, to find out whether the sum of the discounted social benefits during the lifecycle of the can outweigh its investment cost. The paper develops a framework of appraisal that identifies the direct and indirect potential sources of benefits of the proposed corridor and uses that framework to estimate these benefits over the project life. The appraisal framework and procedures consider passenger operation only, leaving aside freight operations. Cost-benefit analysis (CBA) is employed as an evaluation tool to compare the NPV of all the direct and indirect costs, and social benefits.

The Egyptian operating railway network has a total length of 5,195 km and is used for passenger transport and freight transport. Sixty percent of the network is concentrated in the Nile Delta and along the Nile Valley. The network reaches most of the Egyptian population, even relatively small population centers are served by minor lines. However, these lines are mostly used by small and poor quality trains. Currently, 30.6% of the railways are double track and 0.84% is four tracks. It's considered the backbone of passenger transport in Egypt, where the volume of railway passengers is about 500 million annually of which 1.4 million passengers daily and about 6 million tons annually of goods.

Rail infrastructure is owned by, and rail services are provided by, the Egyptian National Railways (ENR), a public entity created in 1980 and reporting to the Ministry of Transport (MoT). ENR is one of the big economic institutions in Egypt and Arab nation. It the largest institute in of passengers and freight transportation, and is considered the backbone for transporting people in Egypt. Although ENR has a significant role in passenger transportation (carrying about 40% of total passenger traffic) it has a minor share of freight transport (only about 6%). In 2011, number of rail passengers excluding the Metro was about 451 million representing 40,837 million passenger kilometers, with an average travel distance of about 90 km. The annual average growth ratio during 2000-2011 of the number of rail passengers and passenger kilometers was -15 % and -31.1% respectively. The total rail freight transport volume and total tonnage kilometers were 5 million and 1592 million in 2011. The average transport distance is estimated to be about 318 km. Annual average growth ratio during ratio of tonnage to the total tonnage kilometers during 2000-2010 was -25 % and -12.4% respectively.

ENR has been suffering from a deficit since 1975 [6]. The cost-recovery ratio (defined as revenue divided by expenses) went down to 33–34% in the middle of the 1980s. However, the current deficit excluding depreciation has been improved gradually in the 1990s. Consequently, the cost-recovery ratio went up to 107% in 1994/95. On the other hand, including depreciation in 1994/95, the cost-recovery ratio was still below 100%. In addition, ENR has not been paying interest cost since 1992/93. If this was included on the income statement in 1993/94, for example, the cost-recovery ratio would be down to 43%. So ENR is still facing financial deficit, especially a large burden of capital cost [6].

However, number of passenger by rail transport is decreasing in the recent years, due to the poor service and the accidence. Furthermore, passenger traffic steadily developed from the early 1995s until 2003 (when it reached a record 46,431 billion passenger-kilometers). Since 2004 traffic has reached 53,638 billion passenger-kilometers until 2006 (approximately the same number of passenger in this period), after this the number of passenger/km is decreasing. However, decreasing is probably due to the increase in first class fares 10% and the introduction of passenger insurance levy to all classes [7]. It is clear that, the activities of ENR have been divided in four business units since 2008, this activities including: Long distance and Short distance passenger services; local services; suburban and special service; additional to the freight transport services. Thus, the important categories will be discussed in this study is the long distance passenger service, while this term of the service is the most important in the long-distance transport in Egypt. In addition to revenue may be significant to cover operating costs.

In most countries, a minimum level of traffic is required to start examining the feasibility of high speed railway. Japan Railways identify a minimum "turnout point" of 40 trains per day [8]. The World Bank studies of electrification of high speed rail identify a minimum level of traffic before proceeding with appraisal [9]. In Europe, most railway proposals have to go through both financial and economic evaluation, and have to yield sufficient direct and indirect benefits to justify the initial capital investment of the proposed lines [10]. This can only happen if railway lines have a high level of traffic demand.

2 Literature review of HSR

Compared with the conventional railway, HSR adopts a break-through technology that can shorten the transportation time and thus increase its market share for medium range traveling distances. Lots of research works about economic evaluation of HSR have been conducted in the past twenty years. Nash (1991) provided a general assessment of HSR and claimed that the principal benefits of HSR were the revenue and traffic time savings [12]. He also pointed out that there was lack of evidence in supporting that HSR would bring about any environmental and regional development benefits. At last, Nash (1991; 2009) concluded that HSR was the most cost-effective solution only for the middle distance range (around 500 kilometers) transportation [12]. De Rus and Inglada (1997) carried out an economic evaluation of the Spanish HSR project by using the CBA method [2]. The results recommended that the project should not be carried out in 1987 in that particular corridor due to its huge negative NPV. Brand (2011) also applied CBA to the proposed HSR in California and focused on the calculation of benefits pertaining to intercity HSR user, highway traveler, and air travellers [13]. He drew the conclusion that the major benefits included the revenues derived from HSR user, the HSR user benefits (consumer surplus) net of fares paid, the travel time savings to urban commuters, and the value of time savings to intercity air travelers. A general review of the HSR developments in Europe was done by Vickerman (1997). He put forward two main points: first, the HSR had the natural effect of increasing the concentration of economic activities among each region; second, HSR could bring positive development benefits under a careful planning and ancillary policy intervention [14]. Martin (1997) established a relationship between the NPV of HSR projects in terms of their social value, transportation consumers' benefits and regional economic impacts [15]. The results showed that if the NPV was positive, the HSR project could generate regional growth even if no bottleneck existed before the project.

The project is proved to be unprofitable under all scenarios with a negative NPV which is mainly due to the limited travel time savings of a mere ten to fifteen minutes. De Rus (2008) summarized eight main benefits of HSR, i.e. travel time savings, increase in comfort, generation of new trips, reduction in congestion and delays, reduction in accidents, reduction in environmental impact, release of needed capacity in other transportation modes, and wider regional developments [4]. In addition, he evaluated the HSR investment within the CBA framework and found that whether to build HSR or not was largely dependent on the existing volume of traffic, the expected travel time savings and the average willingness to pay by potential users, etc.

In accordance with Nickel et al. (2009), HSR had two main types of benefits, namely the first order effects (i.e. travel time savings, emission reduction) and the second order effects (i.e. long-term and short-term job generation, attraction of new business development, and increase in property value [16]. Janic (2011) conducted a sensitivity analysis of particular savings with respect to changes of the most influencing factors, i.e. the number of air transport flights to be substituted after evaluating the partial substitution of some air transport short-haul flights with HSR services [17]. Results showed that the HSR substitutive capacity was not a barrier to develop air transport/ HSR substitution at the airport. Thereby, in order to check the stability and reliability of the proposed HSR in Egypt project, sensitivity analysis is applied in this study as well.

Based on the previous critical review of HSR, whether an especially HSR investment is cost-effective cannot be judged unless a full-scale evaluation is provided. However, research works about evaluation of the economic and social effects of proposed Cairo- Alexandria HSR are of paucity. This paper intends to apply the CBA method to assess the HSR project in Egypt and determine whether the aggregated social benefits can justify its investment costs.

3 Evaluation of proposed outline HSR

3.1 Project description

The Cairo-Alexandria railway line, 208 km long, is one of the main lines of ENR. Now ENR service operates on the Northeast Corridor similarly to other Northwest Corridor regional services. It carries about 30% of ENR passengers. Each major city has a central train station. In Cairo, it is Ramses Square; and in Alexandria, it is Sidi Gaber and Masr station (Figure 1). The study of opportunities of HSR in Egypt identified the daily number of passenger trains operating on the line is 65 in each direction with allowable speed up to 120km/h. Some of these 32 are express trains (air-conditioned trains, mixed trains, and those that are not air-conditioned) that operate on the whole distance between Cairo-Alexandria [3]. The other 33 are local trains that operate between one point and another on the line. The line has the highest passenger density (200 to 214 thousands passenger per day) of the entire ENR lines. Most of the line is flat, gradients are rare and do not exceed 0.5%. The track gauge is about 1435 mm. Figure 1 illustrates the existing Egypt's rail network and illustrates the proposed line for Cairo-Alexandria HSR line.

This paper is concerned with examining the investment and economic viability of proposed Cairo-Alexandria HSR line. The paper develops a framework of appraisal that identifies the direct and indirect potential sources of benefits of the proposed line and uses that framework to estimate these benefits over the project life. The appraisal framework and procedures consider passenger operation only, leaving aside freight operations. By means of this new HSR corridor, the journey time between Cairo and Alexandria would be reduced from about 3.5 hours to 65 minutes (see Table 1).

3.2 Financial and economic evaluation

At the most general level, the techniques for assessing investment in the transport sector are financial assessment, economic assessment, and multi-criteria decision-making techniques. However, there are two techniques and it will be highlights how they vary in assessing investment plans.

3.3 Financial evaluation

Financial evaluation is a method by which the effects of an investment on a particular industry, private or firm investor can be measured. The main face of financial evaluation is that it considers only the direct effects of the project on the project owner (railway operator) on a cash basis. The second aspect is that it accepts actual prices in the market (at the time of evaluation).The external impacts of the project on the rest of society or direct impacts on the consumers of the service provided and resource cost adjustments (pricing shade) are all irrelevant in the financial evaluation technique.

In the transport sector, many investment projects, such as HSR lines, have effects other than on the entrepreneur (railway operator), such as benefits to users (improvements in service quality) and benefits or costs to society (reduction in external costs of road transport such as congestion relief and accident reduction). These impacts are not included in the financial evaluation framework.

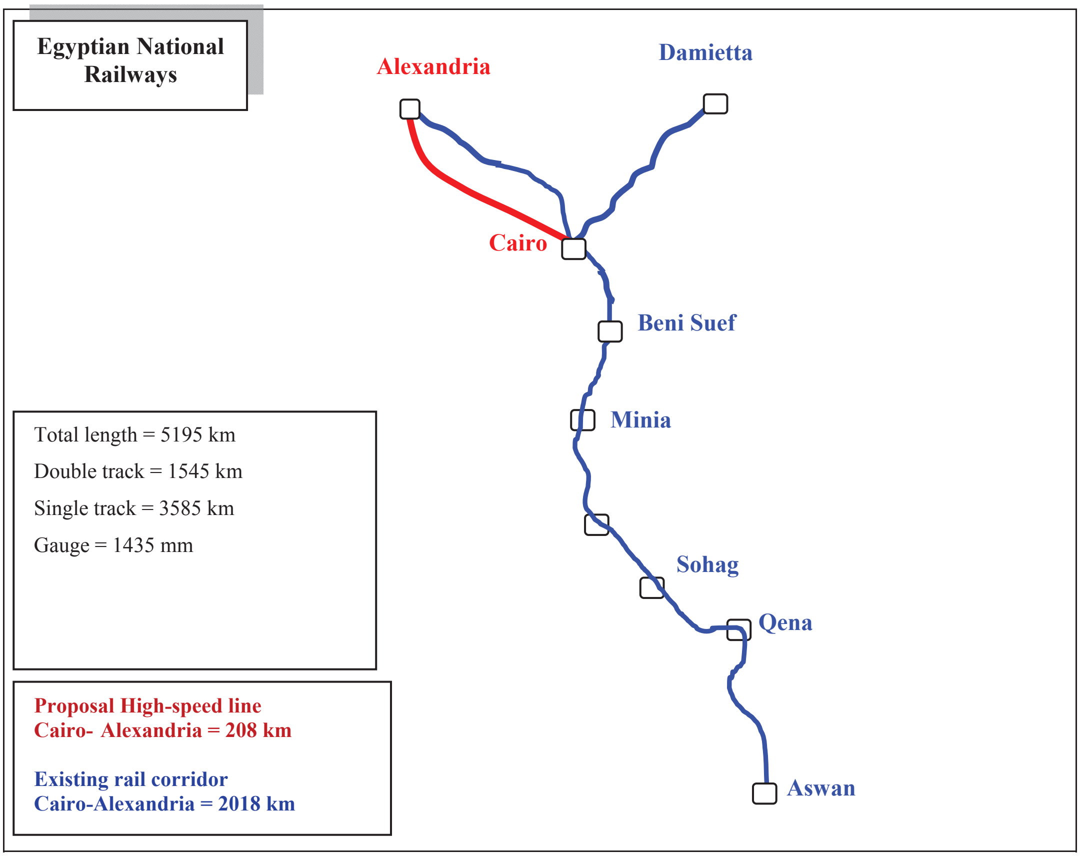

Figure 1: Existing and Proposal Route of Cairo-Alexandria proposed HSR line

3.4 Economic assessment (cost-benefit analysis (CBA))

CBA is the most popular technique for carrying out economic appraisal for transport investment projects. CBA has been widely used to support the decision making process in transportation by evaluating the potential social and economic impacts of each alternative [17]. CBA aims to evaluate a set of direct and indirect effects of a project, its financial and non-financial effects on a set of economic agents concerning with the investment [18]. Thus, over the last decade, the accuracy of this technique has been greatly improved with the new evaluation criteria such as the measurement of the willingness to pay by the potential passengers, the reduction of carbon emission and accident risks, etc. Nowadays, CBA has become one of the most widely accepted and applied methods in project appraisal for large-scale infrastructure investments in the public sector [15].

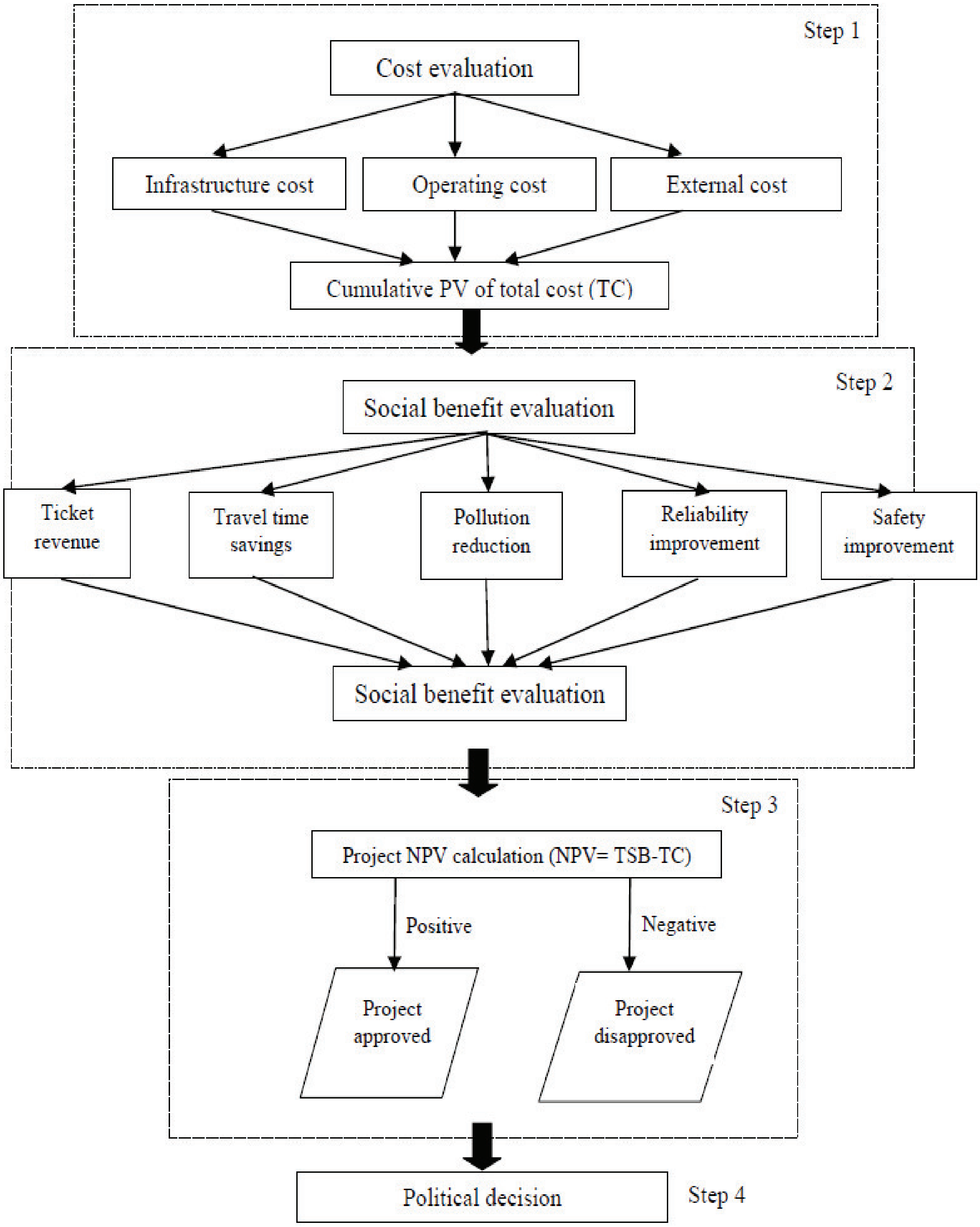

Figure 2: The Proposed Research Framework

The proposed research framework of this paper is presented in Figure 2. The CBA evaluation process is divided into four steps. The first is to estimate the total cost which is composed of the infrastructure costs, operating costs and external cost. All the future values are discounted into PV and aggregated as the cumulative PV of total cost (TC). By applying the same principle, the cumulative PV of total social benefit (TSB), which consists of five main components, can be worked out in the second step. The third is to subtract TC from TSB, so that the project NPV could be obtained for the project appraisal. In order to further support the approval of HSR investment, additional comparisons of HSR with other relevant transport alternatives, i.e. the existing roadway and conentional railway are performed in the fourth step.

4 Cost estimation

The project costs can be divided into three groups: fixed, semi-fixed and variable, naturally depending on the term considered. Fixed costs are those corresponding to the construction of the infrastructure (in the widest sense) and its maintenance. Semi-fixed costs correspond to the purchase of rolling stock and, lastly, variable costs are those commonly called operating costs [4], characterized by being highly sensitive to the evolution of the demand.

4.1 Costs of infrastructure construction

The infrastructure cost includes the track as well as the earthworks, signalling, stations, catenary, etc. The infrastructure costs of a new HSR involve: planning and land costs, infrastructure building costs and superstructure costs. The infrastructure costs are by using the average kilometer construction cost (Cc) dependent on the line length (L). Table 1; shows all parameters in the Cairo-Alexandria. According to [3], the construction period of the proposed Cairo Alexandria HSR line is five years. The total infrastructure cost/ initial outlay (C_i) is €1.65 billion. The planning and land costs reach up to (α) 10% (€ 0.17 billion) and the infrastructure building costs and superstructure costs take up the rest 90% (€1.49 billion). The information about the construction costs has been collected from the informative studies of the corresponding projects.

$$I_c = \sum_{t=1}^{T} \frac{(c.L)(1+\alpha)}{(1+i)^t} + \sum_{t=T_0+1}^{T} \frac{m.L}{(1+t)^t} \quad (1)$$

Where:
α= the planning and land costs
i= the social discounting rate. Given the high rate of inflation in Egypt, 6% social discounting rate is applied in this paper [19; 20].
t:= the year in operation;
T= the project's life expectancy is 40 (years).

It can be noted that the actual values of the average construction cost per km were estimated as show in Table 2 from analysis some HSR project. Therefore, in particular it will not consider one value, but three values: the lower value, average value and the highest value of construction costs.

	Cairo- Alexandria
Line length (km)	208
Average cost per km	10 million
Project timeline	40 years
Initial annual demand in 2015	20.7 million passenger
Growth factor (g) every 5 years	2.81
Train capacity (q) seat / train	1026
Load factor (l)	80%
Operating hours (daily)	20 hours
Average commercial speed (s) =	250 kms/h

Table 1: The main Parameters of proposed Cairo-Alexandria HSR line

4. 2 Infrastructure maintenance costs

The annual maintenance cost for the infrastructure has been estimated at 13000 Euros per km, taking as reference the average value of the costs of informative studies of the corresponding projects [3], which are already operative. Table 2; shows the some results from the calculation for this study (Cairo-Alexandria proposed corridor in Egypt). It can be noted that; the total infrastructure cost is fixed cost that means evolve linearly with the length of route.

	Egypt	
	Cairo- Alexandria	
	Construction	Maintenance
Line length(km)	208	
Cost value [€ per km]		
Lower value	10,000,000	13,000
Medium value	17,000,000	30,000
Higher value	30,000,000	33,000
Planning and land cost [α]	10 %	-
Interest ratio in years	3 %	
Residual value (-)	- 30 %	-
Total value [€ per year]		
The best value	41,240,000	5,400,000
The medium value	70,110,000	12,480,000
The worst value	123,720,000	13,952,000

Table 2: Annual Infrastructure Cost for proposed HSR in Egypt

4.3 Residual value of the infrastructure

In additional to the previous calculation of costs in the Table 2, it will be considered the residual value of the infrastructure at the end of the project (at time = 40 years).

Where this value (once discounted in the beginning of the project) reduces the total infrastructure cost. Thus, to simplify calculation it will just assume that value equals to 30 % of total construction cost for each scenario according to [21]. Furthermore, it will be also assumed the 3.0 % of the annual total cost is typical of expected market of interest rates (The total cost of building may differ from the assumed value of 3.0% interest value for Infrastructure. Furthermore the interest value may be different interest rates (1%–10%) between the unit cost of infrastructure, rolling stock, and noise damage, where infrastructure is assumed to be depreciated over an infinite time period (life time of project), rolling stock over 25 years and noise damage over 15 years).

4.4 Total variable cost

This cost is divided into three groups; rolling stock acquisition, operation cost and maintenance cost.

4.5 Rolling stock costs

The costs considered for the different types of rolling stock (Acquisition, Maintenance and Sales Tax costs) (locomotive and wagons) are as follows: € 227.02 million and €13.85 million, according to data provided by the [3] and taking into account that the route does not necessarily require it to be high technology, given that the speed being aimed for is 200 km/h instead of 250 km/h. In additional, The general sales tax on train is assumed to be 5%, because the tax is applied to all sales transactions, the value of tax sales is €1.54 per train. The total train's number of the project can be calculated from total number of passenger according to [3]; so, the number of trains between Cairo-Alexandria is 9 trains per day. Accordingly to this number will estimate the variable costs (the acquisition and maintenance costs) of train as in Table 3 (Note: the life time of project is assumed as 40 years). For the expected life assumed of 20 years and no residual value. Table 3 explains the cost of rolling stock depends on the number of seats, so the train with large capacity seats is better to be chosen, because this leads to reduce maintenance costs, in addition to reduce the number of departures.

	Egypt
	Cairo-Alexandria
RSC Acquisition	(9× 30000 × 1026)= 277.02 million 9 × 30,780,000= 277.02 million
RSC maintenance include the interest and depreciation of rolling stock	(9× 3000 × 1026) = 27.702 million 9 × 30,780,000= 27.702 million
Sales Tax costs	(9×30000×1026)×0.05= 13.85 million 9 ×1,539,000 = 13.85 million

Table 3: Annual Rolling Stock Cost

4.6 Operating costs

This cost includes all costs derived from operating (power, staff, maintenance of rolling stock and services, such as catering, video, etc.) and we take as reference the operating costs of the proposal line Cairo-Alexandria in Egypt provided by study of HSR in developing countries. This cost is: (energy cost €4.75 million / years; Sales and administration costs €16.6 million /years; Labor cost on board the train € 0.91million respectively)

5 The result of costs estimation

The construction and operations costs considered; all direct and transacted according to the previous section, particular in Table 4. In this section have been identified all the costs for the proposed corridor. Whereas, figuring in essential contingency and add on costs, estimated their systems fixed cost at €1.650 billion (C_i) €41.25 million/year). In additional, the maintenances costs (C_{m1})€5.4 million/year will be added to this value (It should be noted that, these costs are the total fixed cost, with adding the interest rate and discount the residual value). Thus, it can be assumed to represent a conservative estimate for an average €10 million/km. This figure covered the necessary land purchases and planning cost is 10%. Addition to this, the purchase price of each trainset of fourteen passenger car and two power cars is estimated at about €30.78 million, again based on the conservative assumptions used by Table 3. Every train can carry up to 1026 passenger, but it will be taken the loading factor about 80 %. Therefore, total of nine and trainsets are expected to be necessary for project implementation, assuming that about 15 % of the train are not in service at any given time, and should be avoided this value. But in this example, will take the all acquisition costs of trainset to estimated benefit cost ratio.

It can be also estimated that rolling stock have useful lives of 20-30 years, requiring that trainset be acquisition during lifetime (40 years) of project and that their price be figured into the economic analysis. Moreover, the total cost of acquisition rolling stock estimated their systems fixed cost at (C_{acq}) €277.02 million [6.93 million/year], addition rolling stock must be purchased as demand increase throughout the project life; these too are included in the calculation of costs. The operating cost of HSR services is about 41000 per seat per year. Addition to this the maintenance cost and sales tax costs which were calculated in Table 6. The capital costs also will include the operation cost of (energy and personal labor costs), this value estimated of €5.66 million/year, for the sales and administration the value will be €16.6 million/year, thus, the total energy and personal labor costs is $(C_{operation})$ €22.26 million/year. Thus, the rolling stock maintenance cost (C_{m2}) €27.702 million/year will be added. For the sales tax costs will be adding these values only one times for the total costs this value about (C_{Tsales}) €13.85 million [See all calculation in Table 8].

			Cairo-Alexandria
Line length [km]			208
Fixed infrastructure cost per year [million]	Construction cost (C_i)		41.24
	Maintenance cost (C_{m1})		5.40
Variable cost per year [million]	Train acquisition (C_{acq})		277.02
	Train sales tax costs (C_{Tsales})		13.85
	Rolling stock maintenance cost (C_{m2})		27.702
	1. Labor cost on board the train	$(C_{operation})$	0.91
	2. Energy cost		4.75
	3. Sales and Administration costs		16.6
	Total operating costs of HSR services (1+2+3) $(C_{operation})$		22.26
Total cost per year [million]			387.47
Passenger-kilometers [billion Pkm]			3.453
Cost/ train-km [€/train-km]			15.3
Cost of passenger-km [€/Pkm]			0.112
Average demand volume of passenger [million/year]			16.6
Fare price per journey			23.34 €

Table 4: Result of Costs Estimation for Proposed HSR Cairo-Alexandria

5.1 Cumulative PV of total cost

The cumulative P_{VC} of the total cost (TC) of the Cairo-Alexandria HSR Proposed is equal to the sum of fixed and variable cost that is € 387.47 million as show in Table 4, using the following equation.

$$TC = \sum_{t=1}^{T} C_i + C_{acq} + C_{Tsales} + C_{m1} + C_{m2} + C_{Operation} \quad (2)$$

Where:

i= the social discounting rate 6%

t:= the year in operation;

T= the project’s life expectancy is (40 years).

6 Social benefits

The main sources of social benefits arising from the investment of HSR involve not only the general economic benefits, i.e. ticket revenue, but also the other social benefits like travel time savings, pollution reduction, reliability and safety improvement. Although some researchers believed that HSR would speed up the regional economic development, the empirical evidence suggested that transport infrastructure was only a necessary condition for economic development. It is hard to accept that HSR changes substantially the basic parameters of the regional economic development [2].Therefore; this paper only estimates the aforementioned five main types of social benefits.

1. **Direct Revenue Benefits (ticket revenue);** Direct benefits can be obtained by multiplying appropriate fares by the number of passenger per year, B_{tr} = 16.6×23.34 = €387.44 million (this result according to the data from a Table 4). Non traded Benefits and external factor; The other non-traded but direct benefits exist, like as do reductions in the negative external factors. In theory benefits can be traded they include increases in consumer surplus and safety and diminished noxious emissions. As for the external factors, such as air pollution, occur when one person's actions and impose either cost or benefits upon others. Also it is promises abated noise, lessened land taking, congestion reduction and accidents.

2. **Riding a train is safer,** on average than traveling by cars but not quite as safer traveling be airplane. Thus, cars are currently responsible for about 1.61 deaths, 61 injury accidents and 374 other (such as solely property) accidents per 100 million passenger miles travel. Conversely, railway claim about 0.06 deaths and airplane about 0.03 deaths per 100 million passenger miles [22].The claims that road traffic accidents cost Egypt in year 2008 estimated 16 billion EP [2 billion Euro] [23].Comprehensive costs to account for quality of life aspects and in some case, where now in Egypt people's willingness to pay more to prevent accidents, on this basis, safety of train is the most important way to benefits of reducing accidents. Consequently, it can be found that the cost of accidents about € 30.9 for cars and € 0.74 for rail and €0.37 for air per 1000 passenger kilometers [22]. According to [3] the cost of accidents about €0.009 per pkm in Egypt. But it will use the data as estimated by [22], about €0.00074 pkm. Consequently, using this value the HSR would generate yearly accidents saving by multiply the total number of passenger kilometer by the cost per pkm, and this give about (B_{si}) € 2.56 million per years for the Cairo Alexandria proposal HSR in Egypt.

3. **Air pollution** through emissions is currently an externality and not priced directly. According to Envitrak the airplane used an average 2.88 kWh per passenger kilometer and car used an average of 1.44 and the high speed train only need to 0.38. However, the average cost of the automobile about € 10.1 per 1000 Pkm, €5.1 Pkm for the rail, and € 0.2 per 1000 Pkm [22]. Thus, to be conservative in valuing the air quality benefits of HSR, it can be assumed according this date in a cost of € 0.0051 per Pkm air pollution cost. The total cost benefits from the air pollution. Using these as estimates, HSR would generate yearly emissions saving about (B_{pr}) € 17.61 million per years for the Cairo-Alexandria proposal HSR in Egypt.

4. **Travel time savings**: The total user travel time includes access and egress time, waiting time and within vehicle time. According to [4], when the original mode is a conventional railway with operating speed below 100km per hour, the HSR will save 45-50 minutes for distances in the range of 350-450 km. While comparing the proposal three routes in Egypt with the conventional railway, assuming that they both have the same access, egress and waiting time, HSR will save about 40 minutes. In addition, the average value of travel time savings is equal to €1.32 per person per hour with an assumption of the traffic composition of 50% business trips, 30% commuting trips and 20% others [24]. Therefore, the average annual social benefit of travel time savings could be derived as (B_{ts})€ 22 million per years.

5. **Reliability improvement:** The unreliability in travel time is one of the biggest problems in transportation. HSR can effectively reduce such kind of uncertainty and improve the reliability level in terms of avoiding congestion and delays. Compared with roadway and conventional railway, HSR has outstanding reliability benefits which should be included in the CBA [25]. The value of reliability improvement is estimated based on the ratio of value of travel time savings, which is about 13.7% [26]. Thus, the annual social benefit of reliability improvement is about (B_{ri}) € 3.01 million per years.

Indirect Benefits and cost: in addition to those benefits mentioned above, the HSR system will bring other opportunities and benefits to the country that cannot be quantified. In Figure 1b it can be observed that the proposal high speed rail in Egypt will run in the western desert, this mean that HSR line may be increase generate and a new movement and transfer of congestion of population from the Nile Valley to the Western desert. HSR maybe helps to reducing the major problem in Egypt, this problem is related to accidents on the roads. As well as airplane in Egypt did not use a key alternative in the transport of passengers, due to the high cost and takes a long.

7 Cumulative PV of total social benefits

The cumulative P_{VB} of total social benefits (TSB) can be worked out as € 432.65 million using the following equation.

$$\text{TSB} = \sum_{t=1}^{T} (B_{tr} + B_{ts} + B_{pr} + B_{ri} + B_{si} \tag{3}$$

The NPV of HSR: The NPV of HSR is equal to the cumulative discounted P_{VB} of total social benefits (TSB, € 432.65 million) minus the cumulative discounted P_{VC} of total cost (TC, € 387.47 million). The result of this paper shows that the proposed HSR has a positive NPV (€ 45.18 million), which demonstrates that the project provides net gain in benefits and thus is worth to be carried out.

8 Sensitivity analysis of CBA

The accuracy of CBA is easily affected by some erratic elements such as population size, the economic growth rate, different levels of transportation services and competitive pressures exercised by alternative modes of transport. In order to insure that the results of CBA is stable and reliable, sensitivity analysis is applied and to provide a general idea of the extent of the potential impacts given by the elements mentioned above. Considering the previous discussion, the operating costs of HSR services, which include the costs of labor, energy and other materials consumed by the tracks, terminal, traffic management and safety systems, etc. $(C_{operation})$ is probably to be affected by alteration of design, duration and some other factors which usually happen during the construction process. In addition, it takes a large proportion of the total operating cost of the project. Therefore, $C_{operation}$ is altered in the range of -30% to +30% with an interval of 10%. The results in Table 5 show that the NPV changes from -14.79% to +14.79% accordingly, and when $C_{operation}$ increases by 50.50%, the NPV decreases to zero.

% Change in $C_{op.}$	Actual $C_{op.}$	Total Cost (TC)	NPV	Change in NPV (%)
-30	15.58	380.79	51.86	14.79
-20	17.81	383.02	49.63	9.85
-10	20.03	385.24	47.41	4.94
0	22.26	387.47	45.18	0
10	24.49	389.7	42.95	-4.94
20	26.71	391.92	40.73	-9.85
30	28.94	394.15	38.50	-14.79
50.50	67.44	432.65	0	-100

Table 5: Sensitivity analysis of the impact of changes in $C_{operation}$ on net present value (NPV) of the project (€, million)

Annual rolling stock maintenance cost (C_{m2}) included in operating cost of Cairo-Alexandria proposed project is another influence parameter which has much effect on the NPV. This factor is also made to fluctuate within the bounds of - 30% to +30% in Table 6, which causes the change in NPV floats between -18.38% and +18.38%. Meanwhile, the highest value NPV in this range is € 36.87 million. For the total social benefits, passenger flow per day is no doubt a crucial factor. It is revealed on the ticket revenue (B_{tr}) and has a direct impact on the total income of this project. Hence, in some sense, it plays a make-or-break role in this project. In Table 7, the NPV is estimated with every change of passenger flow by 10% in the range of -30% to +30%. It reveals that the NPV will always be positive till the passenger flow reduces by 11.70%.

% Change in C_{m2}	Actual C_{m2}	Total Cost (TC)	NPV	Change in NPV (%)
-30	19.40	379.17	53.48	18.38
-20	22.16	381.93	50.72	12.26
-10	24.93	384.7	47.95	6.13
0	27.70	387.47	45.18	0
10	30.47	390.24	42.41	-6.13
20	33.24	393.01	39.64	-12.26
30	36.01	395.78	36.87	-18.38
43.85	72.88	342.65	0	-100

Table 6: Sensitivity analysis of the impact of changes in C_m on net present value (NPV) of the project (€, million)

Change in passenger flow (%)	Actual passenger flow (million)	Total revenue (B_{tr})	Total Social Benefit (TSB)	NPV	Change in NPV (%)
-30	11.62	271.21	316.42	-71.05	-257.26
-20	13.28	309.96	355.17	-32.3	-171.49
-11.7	14.66	342.29	387.47	0	-100
-10	14.94	348.70	393.91	6.44	-85.76
0	16.6	387.44	432.65	45.18	0
10	18.26	426.19	471.40	83.93	85.76
20	19.92	464.93	510.14	122.67	170.61
30	21.58	503.68	548.90	161.43	257.30

Table 7: Sensitivity analysis of the impact of changes in population on net present value (NPV) of the project (€, million)

All the analysis above indicated that the different factors which would have potential effect on the NPV of the Cairo-Alexandria proposed project have a great extent for changing and will not lead the project to failure. As shown in Table 8, despite of the highest capital cost, the investment of HSR still provides the largest positive NPV with more than €45.18 million.

9 Summary of results

Each mode of passenger transportation has its own advantages and disadvantages. The evaluation of the HSR investment should not focus on the sum of NPV only, but the comparison of the other relevant transport alternatives (i.e. the existing roadway and conventional railway) as well. Table 8 summarizes yearly costs and gains. The effects have been divided into consumer surplus effects, ‘‘other’’ effects directly affecting the citizens, public costs and revenues and finally marginal cost of public funds and correction for indirect taxes. The present analysis demonstrates that the Cairo-Alexandria system yields a large social surplus, well enough to cover both investment and operating costs. The value of the time gains compared to the paid charges is remarkably high compared to most theoretical examples.

Finally, the study may offer some lessons for evaluation procedures. It shows that many social and environmental costs and benefits can and should be included in the cost-benefit analysis: this brings out the critical elements in the policy decision within a coherent and consistent framework. So, many assumptions about the environment were required. But the assumptions about the environment were generally no more heroic than those about transport, even though more thorough evaluation procedures have been developed for transport than for most other sectors. Results have been achieved reasonable and coherent despite the extreme difficulty of obtaining data in Egypt, which described by the author. On the other hand, the evaluation would have benefited from more study of network impacts, local and regional land use impacts, and from a social impact assessment analysis.

	Corridor Cairo-Alexandria
COSTS (€M)	
Infrastructure Costs	41.24
Maintenances Infrastructure costs	5.4
Acquisition Rolling Stock	277.02
Train Maintenance Cost	27.702
Train Operating (Energy and labor personal costs)	5.66
Sales and Administration Costs	16.6
Sales and Tax Costs	13.85
Total Costs $[P_{VC}]$	387.47
BENEFITS (€M)	
Passenger Ticket Revenue	387.44
Lives Saved	2.56
Air Quality	17.61
Travel time savings	22
Reliability improvement	3.01
Total Benefits $[P_{VB}]$	432.65
Net Present Value [NPV] = Total Benefits $[P_{VB}]$- Total Costs $[P_{VC}]$	45.18
Benefits Cost Ratio for Economic Case $B_{CR} = \frac{P_{VB}}{P_{VC}}$	1.12

Table 8: Result of the Benefits Costs Analysis Proposal HSR in Egypt

10 Conclusion

Traffic congestion, accidents, and air quality are serious problems in Egypt. Emission controls on motor vehicles, efficient pricing policies, and traffic management are the most cost-effective instruments for reducing congestion and pollution. However, they would not provide a complete solution. The Cairo-Alexandria corridor is considered the first major opportunity for improving the rail transport infrastructure. The internal rate of return estimated for the proposed railway is 2.5-3.0%. The majority of the benefits are relieved crowding and reduced travel time. There will be significant savings in accident costs and benefits of air quality, but other environmental benefits to be simple.

A cost benefit analysis is a useful tool for HSR in principle; it is also a difficult task. But the methods differ and unanimous agreement on how to perform these analyses has not been gained. It can include external impacts of HSR. It is difficult to make an accurate cost-benefit analysis, due to the difficulties in defining a system boundary and allocating shared costs. The effect of HSR on the external system (such as accidents, environmental externalities, congestion reduction, and social benefits), is also hard to derive, because causality is often unclear. The availability and accuracy of data is another problem. Moreover, the benefit cost analysis is a method that is used in project evaluation and can help in the decision making process of executing it or not. Usually, this process involves the calculation of total expected costs compared to the total expected benefits. Proposed HSR project in Egypt the data was used available (this method can be used in other developing country, if all the conditions that help in doing so these are available). The project seems worthy of serious consideration because of its competitive comprehensive rates of return and ability to be self-financing. The overall net present values for proposed corridor is positive (Cairo-Alexandria) and so the proposed project would increase net benefits to the society. A careful cost-benefit analysis is necessary to assure the feasibility of any HSR projects, and general conclusions about the economic impacts by HSR are hard to establish.

Investing in HSR is a significant social decision. One of the major drawbacks of HSR is its high capital cost. However, the public decision makers should not only focus on the financial cost, but also the potential positive impacts on the society. HSR can bring about some social benefits in terms of ticket revenue, travel time savings, pollution reduction, reliability and safety improvement, etc. A cost-benefit analysis of proposed corridor HSR (Cairo-Alexandria) line is provided in this paper. The results show that this project has a positive NPV up to € 45.18 million and achieves about 11.66% internal rate of return, which fully demonstrates that the investment of this proposed corridor HSR (Cairo-Alexandria) is worth to be carried out. Moreover, other relevant transport alternatives (i.e. the existing roadway and conventional railway) are also examined and compared with the investment of HSR. Because of the excellent performance in ticket revenue, travel time savings and safety improvement, HSR has the largest positive NPV among these three passenger transportation modes. In conclusion, HSR is the most cost-effective solution among the other alternatives for the intercity transport between Cairo-Alexandria.

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