WORLD MARITIME UNIVERSITY
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COST COMPARISON BETWEEN THE NORTH SOUTH CORRIDOR AND THE SUEZ CANAL ROUTE

By

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Iran

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Masoud Mohsenpour

DECLARATION

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

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Abstract

Title of Dissertation: **The cost comparison between the North-South Corridor and the Suez Canal Route**

Degree: **MSc.**

The North-South Corridor is a newly introduced route for transporting cargo between South and South East Asia to Europe. The corridor tries to compete with the convenient route of transport via the Suez Canal and using the northern European ports. This research provides a model to compare the total cost of transport between these two routes. The total cost includes outlay costs, time costs and risk costs.

The high value cargo is assumed in a TEU container. The amounts of costs are calculated per TEU slot, per day at sea and a TEU per kilometer or hour on land transport for road and rail. However the model itself can be useful for other amounts or routes.

Calculations show that the Suez Canal is still profitable according to the N/S Corridor in case of using the total land bridge. This means if the cargo destination is the northern ports of Europe or Scandinavian countries, the Suez Canal is the best choice for transport. Whereas, if the cargo destination is located somewhere inland of central or eastern Europe or in Russia, transport to a certain distance from north of the Iranian territory or north of the Caspian Sea, via the N/S Corridor is profitable. Maps 1 to 4 show the borders between coverage areas of the two routes, and using the N/S Corridor until the red line curves in these maps is reasonable. These curves are named Equi-Cost Curves in this research.

The Black Sea Route is a threat to the N/S Corridor in the future. Another threat is expansion in EU, it can reduce the transit time of transport in eastern Europe, and expand the coverage area of the northern European ports.

The N/S Corridor to expand its coverage area needs to reduce the transit time of transport by speeding up land transport and reducing the idle times at the borders and ports. In addition, it needs to legislate multimodal transport to increase reliability, safety and security of transport; and it needs to recruit information technology to improve efficiency and productivity of transport.

Keywords: North-South Corridor, Suez Canal Route, Northern European Ports Route, Transport cost comparison, Multimodal Transport.

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ASEAN	Association of South-East Asian Nations
BAF	Bunkering Adjustment Factor
CIS	Commonwealth of Independent States
COFR	Certificate of Financial Responsibility
dwt	dead weight tonnage
Equi-Cost Curves	Equal Cost Curves
ESCAP	United Nation Economic and Social Commission for Asia
EU	European Union
EUR	European Currency
FAL	Convention on Facilitation of International Maritime Traffic
FD&D	Freight, Demurrage and Defence
ICC	International Chamber of Commerce
ICD	Inland Custom Depot
INSTC	International North South Transport Corridor
IT	Information Technology
MT Convention	Multimodal Transport Convention
MTO	Multimodal Transport Organization
N/S Corridor	North-South Corridor
OSJD	Organization for Railways Cooperation
P&I	Protection and Indemnity
RAI	Iranian Railway Company
S/E Asia	South East Asia
TEU	Twenty Equivalent Unit
THC	Terminal Handling Cost
UN/CFACT	United Nation Centre for Trade Facilitation and Electronic Business
UNCTAD	United Nation Conference of Trade And Development and the Pacific
USD	United State Dollar

Introduction

As a matter of fact, one of the most important destinations of South-East Asian products is Europe. China, South Korea, Japan and ASEAN countries have good comparative advantages in comparison with the USA for exporting finished products to European markets, thanks to the large number of container ships that are sailing between South-East Asia and Europe. They have a very frequent and regular timetable and reasonable freight. The route handles the traffic from Sweden down to ports in St Nazaire in France to the Far East including ports in Malaysia, Singapore, Thailand, Hong Kong, Philippines, Taiwan, South Korea, China and Japan through the Mediterranean Sea and the Suez Canal, the estimated voyage time is 63 days (for call in every ports) so a shipping company needs to have 9 ships for weekly services (Stopford, 1997, p 369). In 2002, there were more than 432 container ships with a capacity of 709,000 TEU available on the route. (UNCTAD, 2002, p. 19).

The Europe continent imports and exports yearly 8.12 million TEU of finished products (UNCTAD, 2002, p 62) from and to S/E Asia, and during the last 10 years the trade has increased tremendously, for example during 2003 Europe imports from USA decreased 11% but Europe imports from China increased 15%. [*]

The most convenient way to transport cargo from S/E Asia to northern Europe is the Suez Canal Route via northern European ports for the time being, but from long time ago Asians tried to find other possibilities for their transport. The ancient Silk Way from China to southern Europe is the evidence of that attention. One of the most newly introduced corridors for the use of multimodal transport between S/E Asia and northern Europe is "International North-South Transport Corridor", which in this

[*] http://europa.eu.int/comm/eurostat/

research is named the North-South Corridor or the N/S Corridor. Iran, Russia and India are the main countries involved in developing this route.

This research tries to explain the routes itself and make a comparison between the two routes by calculating the total cost of transport for a valuable cargo. The costs are not limited to outlay or transport cost of cargo. It will cover all kinds of expenditures and opportunity costs that are engaged on the route for a specific cargo. For the comparison the research provides a model for calculating all costs related to the routes. The amounts are extracted from several sources and some of them generated by author. The model will be valid for any real amounts; and users can change the values by the new measurements.

By this comparison the research defines the coverage area of each route by sketching border lines named Equi-Cost Curves between destinations that each route can serve them more economically than the other. In the following the effects of some parameters in expanding or shrinking these coverage areas are investigated. Finally recommendations will explain to improve productivity and efficiency of each route, especially the N/S Corridor as a new opportunity for transport.

Chapter 1

General information

When comparing two routes of transport, a definition of the routes, general conditions and means of transport on each route are necessary. The whole picture of the transport possibilities between South East Asia and northern Europe is explained in the following.

1.1 Multimodal transport

Using different modes and means of transport can hardly be implemented without problems; not only the vehicles of different modes have different shapes and need different types of equipment to load and unload, but also the risk of damage and stress on cargo during hand over between modes is high. Multimodality is a challenging activity too; it must keep the goods moving. Any delay incurs cost for the shipper, and continuity in the transport flow must be maintained during the entire transport. Finally, multimodality is a tool to give shippers a wider range of choice to use different routes for transport (Muller, 1999).
However, multimodal transport as a problem, challenge or tool, has produced new opportunities for shippers and carriers to introduce more choices, routes and technologies to not only solve the transport problems and challenge with transport complexity, but also to use it as a tool to improve efficiency and productivity of the trade.

When there are two or more routes to choose between two points, cost comparison is necessary to select a more efficient route.
Cost comparison between two routes by using multimodal transport needs to have fixed bases to calculate different cost sources. One of the important bases for comparison is the origin port of cargo.

1.2 Port of origin

In multimodal transport door to door delivery is an objective. Cargo in this case must be transported from one of the South or South-East Asian countries to somewhere in northern Europe. At the moment there are some hub ports in the South-East Asia that consolidate exports of these countries and prepare them for transfer to other parts of the world, Bussan, Hong Kong, Singapore, Colombo and Bombay are some of these ports. Singapore with a throughput of 18,000,000 TEU in 2003 (Singapore port Authority, 2004) is the largest, because of its location and productivity in the container business.
Singapore is the origin port in this research because it is located in mid way in south Asia between coasts of Japan and India, and also good portion of cargos are consolidated in this port.

Some analysts believe that India will be the next exporter giant in 4 or 5 years. The approved or disapproved of this belief is not dealt with in this research, but to be proactive in results of cost comparison, Bombay would be considered as a future gateway of transport to Europe.

1.3 The routes

There are several choices to transport cargo from South-East Asia to northern Europe; some of them are listed below:

1- Via the Suez Canal, the Mediterranean Sea, the Strait of Gibraltar, Atlantic Ocean, northern European ports.
2- Via the Suez Canal, the Mediterranean Sea, southern European ports, land transport to northern Europe.
3- Via the Suez Canal, the Mediterranean Sea, the Strait of Bosporus, the Black Sea, the Balkan ports, land transport to northern Europe.
4- Via the Cape of Good Hope to northern Europe.
5- Via the Persian Gulf, the land bridge of Iran and Russia to northern Europe (North-South Corridor).
6- The Trans-Siberia land bridge between Asia and Europe.

The most convenient transport route used by shipping lines and shippers is the first one. It is the traditional way for transport between S/E Asia and Europe too. This research tries to make a cost comparison between two of the listed routes: the Suez Canal Route toward the northern European ports and the North-South Corridor.

1.3.1 Suez Canal Route

The route starts from the most remote ports of East Asia like Bussan and calling, Singapore, Jakarta, Colombo and then passing the China Sea, the Malacca Straits, the Indian Ocean, the Arabian Sea, the Red Sea, the Suez Canal, the Mediterranean Sea, the Atlantic Ocean, and calling North European Ports like Le Havre, Antwerp, Rotterdam, Hamburg and go up to Helsinki.(Stopford, 1997)
For a large container ship which handles huge numbers of containers for several destinations, calling every single port on a voyage is not reasonable, because the time in port increases and the ship will loose profitability by high running and inventory costs; therefore liner shipping companies have selected some hub ports for loading and unloading those gigantic ships and smaller feeder ships transport containers from these hub ports to other destinations.
This research assumed only two ports namely Singapore in S/E Asia and Hamburg or Helsinki in northern Europe to estimate the most effective voyage time and cost.

1.3.1.1 Suez Canal

The Suez Canal links the Mediterranean Sea to the Red Sea and historically it is the first man made canal to connect two seas. Further it is located between Port Said and Gulf of Suez. The canal is a sea level canal and the tide is 50 cm in the north and 2 m in the south. It is 78 km long (Suez Canal Authority, 2002).

1.3.1.2 Traffic

The Suez Canal runs in a convoy system, that means ships are allowed to transiting at a fixed speed and fixed separation distance between every two passing ships,

with three convoys; two southbound and one northbound. The piloting starts from the time that the ship arrives at the roadstead to the exit at the other end of the Canal to the open sea. It takes 12 to 16 hours to transit the Canal. The numerical capacity of the canal is about 76 standard ships per day. The Canal is the shortest sea route between east and west in the world. The other route is Cape of Good Hope that makes the distance for example from Bombay to Rotterdam 1.7 (10743/6337) times longer. According to statistics 7 % of the world seaborne trade passed through the Suez Canal in 2002. (Suez Canal Authority, 2002)

1.3.2 North-South Corridor

In 2000 a new route was officially introduced by India, Iran and Russia to transport cargo from the south Asia to northern Europe by using multimodal transport. On this route cargo starts its voyage by sea from Singapore or Bombay to Bandar Abbas in the Persian Gulf and continues toward the north by land transport in Iran, then either on the Caspian Sea by sea transport or Central Asian countries and Russia by road or railroad to Europe. The route is divided into two major parts in this research: The ocean transport part from Singapore or Bombay to Bandar Abbas, and the land bridge from Bandar Abbas to Hamburg or Helsinki as compared to the all-water solution.

1.3.2.1 Ocean transport

There is no complexity in the ocean part, thanks to several shipping lines with good service between South East Asia and the Persian Gulf, but the land bridge needs more investigation from an infrastructural point of view.

1.3.2.2 Land Bridge in the N/S Corridor

The land part of the N/S Corridor as the ESCAP explained, starts from Helsinki in the north of Europe and ends at Bandar Abbas in the south of Iran with 3 possibilities to pass along side of the Caspian Sea.

1- The Caucasus Route connects Finland to Iran through Armenia, Azerbaijan and the Russian Federation.

2- The Central Asian Route connects Finland to Iran via Kazakhstan, Turkmenistan, Uzbekistan and the Russian Federation.
3- The Caspian Sea Route connects Finland to Iran through the Russian Federation and the Caspian Sea (ESCAP, 2001).

Figure 1: 3 possibilities to pass in the Land Bridge
Source: ESCAP, 2001

In this research the route after the Caspian Sea or Caucasus can continue toward eastern and central Europe and destination of Hamburg is considered as well as Helsinki.

1.3.2.2.1 Finland

The Finnish territory is common for all 3 possibilities. The original port for distribution of cargo in the northern Europe is Helsinki, which is connected to Vainikkala, the border town between Russia and Finland. The Railway has a total distance of 283 km and consists of 250 km electrified double track to Luumaki and 33 km single track to Vainikkala. The maximum operating speed is 100 km/h for freight trains and 120-160 km/h for passenger trains. The track gauge is 1,524 mm (ESCAP, 2001).

Figure 2:North South Corridor in Finland

Source: ESCAP, 2000

1.3.2.2.2 The Russian Federation

The Russian territory is common for all the 3 above possibilities only until Volgograd, which starts from Buslovskaya on the Finnish border and passes Saint Petersburg, Bologoye, Moscow, Rtishevo, Saratov toward Volgograd. The 2,513 km railway on

this line with a few exceptions is double track with a maximum operation speed of 90 km/h for freight trains and 120-160 km/h for passenger trains, and over 50% of the distance is electrified. The track gauge in Russia is 1,520 mm.

For the Caucasus route the line continues to Samur from Volgograd by 708 km railway, which include 413 km single-track rail and 295 km double track. It is only partially electrified with a maximum speed of 80 km/h for freight trains and 100 km/h for passenger trains.

For the Central Asia Route, Volgograd is connected to Aksarayskaya by 214 km railway, which is partially double track, and for 52% of the destination it is electrified and the maximum speed is 90 km/h for freight trains and 120-160 km/h for passenger trains.

After Aksarayskaya the railway continues toward the east, and finally connects to Ganushkino of Kazakhstan by the 85 km rail.

For the Caspian Sea Route, 49 km double track railway connects Aksarayskaya to the port of Astrakhan, the main Russian port in the Caspian Sea. It is again 52% electrified and with a maximum speed of 90 km/h for freight trains and 120-160 km/h for passenger trains.

Figure 3: North South Corridor in Russia

Source: ESCAP, 2001

1.3.2.2.3 Azerbaijan

The railway continues in Azerbaijan toward the south from Samur on the Russian border town to Yalama, Baku, and Osmanly-Novaya for the Caucasus Route. The distance is 320 km. It is then divided into two ways; southward to Astara by 185 km and westward to Djulfa by 352 km, including 50 km rail link inside the territory of Armenia. Except 3 km of the entire part of rail from Yalama to Osmanly-Novaya the entire railway is double track and electrified, but the southward junction to Astara and the westward one to Djolfa are both single track and diesel operated. The gauge size in Azerbaijan and Armenia is 1,520 mm. The main entrance to Iranian territory is Djolfa, because the gauge exchange facilities are installed there.

Figure 4: North South Corridor in Azerbaijan

Source: ESCAP, 2001

1.3.2.2.4 Armenia

The Caucasus route has to pass Armenian territory to connect Azerbaijan to Iran by a 50 km long railway.

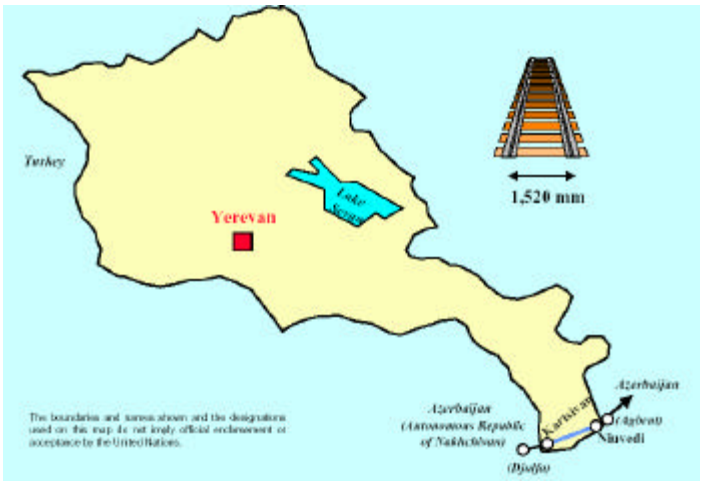

Figure 5: North South Corridor in Armenia

Source: ESCAP, 2001

1.3.2.2.5 Kazakhstan

The Central Asian route continues toward the east from Aksarayskaya on the Russian border in Kazakhstan, and connects Russia to Uzbekistan by an 815 km railroad. It passes Ganushkino, Maket and Beyneu and enters Uzbekistan territory. The railway is single track and diesel operated. The maximum operating speed is 60-80 km/h for freight trains and 60-100 km/h for passenger trains. There is also a possibility to expand the railway into Turkmenistan in the future as shown in Figure 6. It can be connected to Turkmenbashy Port in the Caspian Sea.

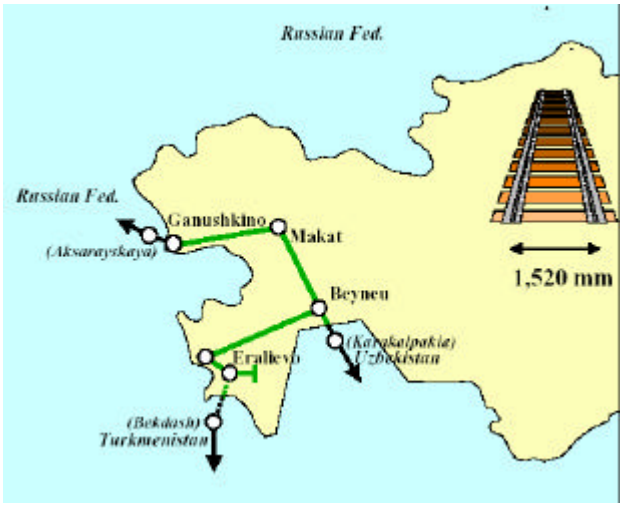

Figure 6: North South Corridor in Kazakhstan

Source: ESCAP, 2001

1.3.2.2.6 Uzbekistan

The railway connects to Uzbekistan railway in Karakalpakia after 100 km out of Kazakhstan territory, and continues to the south to Pitnyak by 593 km passing the territory of Turkmenistan in 72 km. This part is all single track and diesel operated. In 1993 a new railway was constructed to connect Nukuss to Bukhara without passing the territory of Turkmenistan and its distance from Karakalpakia to Khodchadavlet is around 1,250 km with single track and diesel operated.

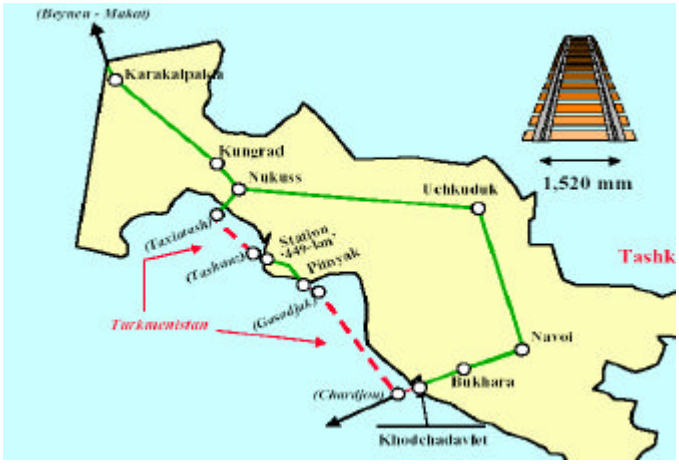

Figure 7: North South Corridor in Uzbekistan

Source: ESCAP, 2001

1.3.2.2.7 Turkmenistan

From Taxiatash the railway continues toward the south till Sarakhs on the border of I.R. Iran. The distance is 1,002 km. but 72 km of this distance passes through Uzbekistan again. The entire section including the 72 km that passed through Uzbekistan is single track and diesel operated.

The Central Asian Route is not used in this research because there are more borders to pass, less safety and security and longer distances on this route, which will increase costs and reduce comparability of the North-South Corridor with the Suez Canal.

1.3.2.2.8 I.R. Iran

All 3 routes finally enter the territory of Iran. Caucasus is connected to the Iranian railway in Djolfa and passes 882 km toward Tehran. The Central Asian Route enters Iran from Sarakhs. In 1996 the section between Mashhad and Sarakhs commissioned, and the landlocked counties in the central Asia found this possibility to connect via Bandar Abbas to the Persian Gulf. By continuing toward the centre of Iran after 926 km, the central Asian route joins to other rotes in Tehran.

The Caspian Sea route enters Iran via two main ports, namely Bandar Anzali and Amir Abad. There is a plan to connect the first one to the Iranian railway, but the second one already connected to the railway network. Amir Abad was constructed in 2002 with a capacity of 2 million tonnes per annum. The distance from that port to Tehran is 300 km.

The route continues toward the south by the connection of Tehran to Bandar Abbas by a 1,443 km double track railroad. The maximum operating speed for freight trains is 60 km/h and for passenger trains it is 120 km/h.

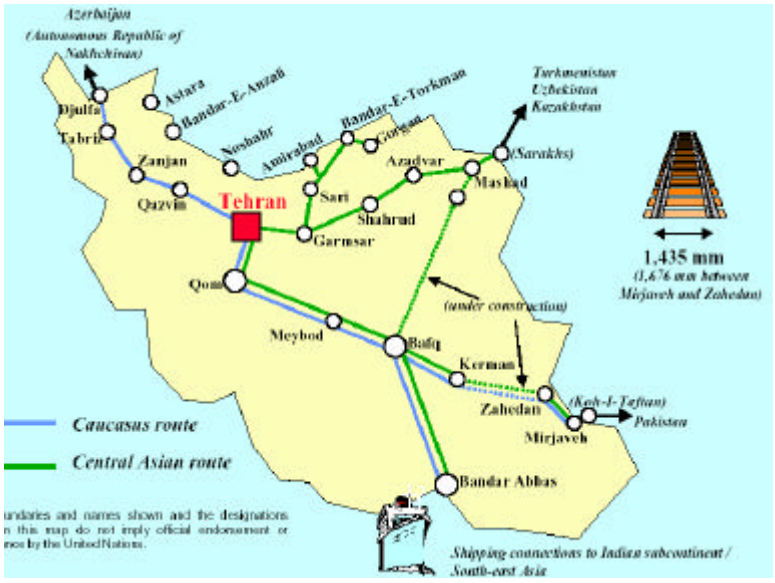

Figure 8: North-South Corridor in Iran

Source: ESCAP, 2001

The Port of Amir Abad and Djolfa are used in this research as the main entrance points for the Caspian Sea Route and the Caucasus Route.

1.3.2.2.9 The Caspian Sea

The sea section on Caspian Sea Route connects Astrakhan to Bandar Anzali or Amir Abad. Its length between Astrakhan and Bandar Anzali is 1,200 km and between Astrakhan and Amir Abad is 1400 km. The depth on both sides is less than 5.5 m and ships with more than 6000 dwt cannot berth in these ports. In addition on the Russian side icebreakers are needed during the winter (ESCAP, 2001).

1.4 Conclusions

A comparison will be conducted between the traditional and the most common rote, the Suez Canal, and early-introduced route, the N/S Corridor; that the first one is mostly sea transport use, whereas the second one is a multimodal transport route via sea, and a land bridge. Both routes suppose to use for export the valuable and containerized cargo from the S/E Asia to the northern Europe. In the next chapter the methodology of this comparison will be discussed, and in Chapter 3, the comparison will take place by using the information of the infrastructures of the two routes.

Chapter 2

Methodology

The comparison between two routes is possible by translating qualitative or quantitative features into some measurable scales. This chapter tries to change important qualitative or quantitative characteristics of the routes into monetary measurements, and evaluate the most important aspects of transport logistics in terms of money. The influential costs of transport services from the shipper's point of view are listed as below:

1- Money outlay
2- Time cost
3- Risk cost

2.1 Money outlay

Money outlay is the direct payment that a shipper should pay to a transport company as a contract to buy specific transport services. It must cover all the logistics, inventory, time and capital costs of transport, tax and benefits of the shipping company. If shipping companies tariffs for all means of transport were available in every country on the route, calculation of the exact money outlay could be possible. However because of lack of published information, the costs of transport on the routes have been calculated and used as the money outlay in this chapter. The money outlay for every means of transport is divided to three parts: Capital costs, and operational costs, plus an overhead for covering offices, buildings expenses, wages and tax, and benefits:

Transport cost = capital costs + operational costs + overhead

2.1.1.1 Capital cost

For installation of a transport means, companies or governments need to spend huge amounts of money to invest in infrastructures like roads, bridges, tunnels and land on road transport or rail roads, bridges, tunnels and land for rail transport or break water, deep channel, basin, berth and port area for sea transport or airports and land for air transport. Means of transport need not only infrastructure but also investment in superstructures like trucks and trailers on roads, locomotives and wagons on rail and ships and airplanes at sea and air transport. Opportunity cost of that huge amount of money can be calculated as capital cost (Ma, 2003, p. 87). For example, if a country would invest money on roads to gain transit of cargo instead of spending capital in mining to supply raw materials, it would suffer from shortage of raw materials, and would have to import raw materials. The amounts of money lost in the mining industry can be considered as the cost of capital for road investments.

Infrastructures and superstructures need maintenance regularly to keep their availability and performance level. The periodic maintenance cost is also part of the capital cost. Assets need periodical maintenance every 2, 5 or 10 years to become younger. The maintenance period depends on: age of asset, maintenance policy, special survey cycle if applicable, and regulations. (Stopford, 1997, p. 154).

Using loans for capital expenditures is very common, because huge amounts of money are involved in these projects. Nobody has enough capital to spend.
Any kind of loan divides the capital cost in some new terms:

1- Capital repayment depends on the size of the loan, the length of the loan, the moratorium, and the currency.
2- Interest payment depends on the source of the loan, the size of the loan, the market interest rate, and the terms of the loan. (Stopford, 1997, p. 154)

2.1.1.2 Operational costs

Fuel, labour, handling and maintenance costs are operational costs; a part of them directly depends on the amount of cargo and distance transported. They are variable costs, and the other parts of these costs are fixed, and in a certain range of changes in distance or tonnage they do not change.

$$\text{Operational costs} = \text{fixed cost} + \text{variable cost}$$

$$\text{Operational costs} = \text{labour} + \text{fuel} + \text{maintenance} + \text{handling}$$

Operational costs are not globalized yet and are different from country to country. These differences can produce comparative advantages, and lead the countries to invest more on transport services, or leave the transport activities and more invest in the other industries.

Cargo volume can affect the operational cost as well. Diseconomies of scale can increase the unit transport cost; it is convenient to find a relation between tonnage or number of TEUs handled in one voyage and reduction in operational costs. It may be reflected in Economies of Scale or Lots of Cargo Factor.

Head bound and back bound balance of cargo can also affect the operational costs. On a route where the cargo is available only in one direction, the operational costs can increase even twice because the trucks, locomotives, ships or air planes must cover operational costs on the return journey too, Factor of Balance can be used for correcting this effect in the total cost.

2.1.1.3 Overhead costs

Administration costs are part of overhead, but still there are other costs that must be covered by tariff as well, such as procedure costs. Any kind of bureaucracy or documentation will cost the transport company. Transport procedures, customs clearance, port storage, sea, rail or road arrangements or any other formal or informal procedures have to be measured as monetary value. Some procedures

directly incur costs like buying the forms, stamps and so on, or the need to recruit someone to care and follow these procedures, like agents for custom clearance. Outsourcing administrative activities is another way. Some other procedures take time, or make looses for the company, so they must be shown in monetary value too.

Benefit and taxes can also be considered as overheads. Every investment needs to return back some profit to the investors. This profit or benefits are considered as a percentage of revenue most of the time. Governments receive some part of these benefits as the taxes to cover their expenditures for community and social support. The tax itself has another application such as controlling and regulating macro economy of the country. For that reason tax policy and the amount of tax is different from country to country. For simplicity the overhead costs including administrative and procedure costs, benefits and taxes are calculated by using a percentage of other costs in this research.

2.1.1.4 Externalities

Every transport service incurs some costs for some part of the community, but at the same time generates new value added for some other parts of the community. For example, transit cargo from a territory of a country produces air pollution by combustion of fuel in the truck engines, water pollution by receiving more ships, noise by passing trains and trucks near by residential areas. Removing this pollution is costly for the community; simultaneously the cargo transition generates new opportunities and jobs for the community, like development of the logistics services in the country, or building new roads and railroads in the rural areas and shopping centres in terminals. These costs and advantages have to be considered in the total cost.

Some countries have strict rules to compensate external costs by direct users, for example the governments ask taxes from the trucks for air pollution or the residents close to roads receive compensation from the governments for noise pollution or reduction on the land price. These external costs have to be added to the total cost and the advantages may be supposed as the indirect benefits, but the calculation

procedure to add all effects individually is very difficult. Most countries do not care enough about the externalities. This research neglects the external costs as well as its advantages for simplicity.

2.1.2 Land transport

The capital costs in land transport include the buildings, depot spaces, vehicles and equipment; and the operating costs are include the maintenance cost of the equipment, the maintenance cost of the buildings, the vehicle standing, the vehicle running, and the overheads staff costs (Ratcliffe, 1987, p. 36). There is an approach to calculate the total cost for transport specific amount of cargo, which introduces the Hour Coefficient and the Kilometre Coefficient The first one is the total cost related to employing a vehicle for each hour of work, and the second one is the total cost related to the loaded vehicle when it moves 1 kilometre. The hour coefficient depends on:

1- Interest and depreciation (fixed)
2- Insurance / risks
3- Road tax, currency vignette, contributions, dues
4- Driver's wages (Incl. all charges and premiums)
5- Others (building, management, administration)

And the kilometre coefficient depends on:

1- Interest and depreciation (variable)
2- Fuel
3- Tires
4- Maintenance, repairs, fines

For a sufficient long period, both coefficients can be calculated by using the average amounts of the firm's recorded data. (Blauwens, 2002, p. 76). However this research tries to calculate the coefficients by roughly summing all the cost sources. The total road transport cost will be:

Total cost = H *Hours + K* Kilometres

H = Hour coefficient

K = Kilometre coefficient

The H and K coefficients are different in different countries because of taxation policy, difference in labour cost, fuel cost and several other reasons. Table 1 shows the differences in 3 regions:

Table 1: H and K calculation in 3 regions in US$

H calcu.	Interest	Insurance	tax	wage	Others	H
Iran	3.13	0.5	0.3	5	1	9.93
Russia	3.13	0.6	0.3	4	1	9.03
Europe	3.13	1.75	0.63	14.38	1.88	21.77

K calcu.	Interest	Fuel	Tires	Maintenance	**K**
Iran	0.04	0.04	0.01	0.02	0.11
Russia	0.04	0.1	0.01	0.02	0.17
Europe	0.04	0.16	0.01	0.03	0.24

Source: Blauwens, 2002 & Author

2.1.2.1 Balance of cargo

As explained before, if the flows of cargo in the head bound and the back bound are equal the vehicles can find enough cargo for the return voyage, and cover their operational costs in return by the freight revenue, but this does not happen on some of the routes. Sometimes the loaded vehicle will return empty after delivering the cargo at destination because of lack of cargo for return. In that case to cover all or part of the voyage costs on the return journey, the freight must increase slightly. To involve the balance or unbalancing of cargo on route expenditures, this research uses the Balance Factor as Bc. If there is a perfect balance on a route, this factor will be 1, but if the flow of cargo on the head bound is greater than the back bound, the Bc. will be more than 1. The explanation is valid for all means of transport. The rail and sea transport have different Bc.'s as well in this research.

2.1.2.2 Economies of scale

Sometimes the vehicle starts a voyage fully laden, because at the time schedule enough cargo is accessible to load fully a vehicle and the vehicle receives the

maximum freight that expected, but on some routes the flow of cargo is weak, or the cargo has a low stowage factor. In this case the transport companies need to increase the freight to cover the cost of empty capacity expenses. This research is using the Economies of Scale Factor Ec. to monitor that effect in freight. Ec. is valid for all means of transport. The rail and sea transport has different Ec.'s as well in this research.

Table 2: coefficients and factors for 3 regions

Road Transport				
	H	**K**	**Bc.**	**Ec.**
Iran	9.93	0.11	1.2	1
Russia	9.03	0.17	1.2	1
Europe	21.77	0.24	1	1

Source: Blauwens, 2002 & Author

In Table 2 the amounts in Europe are measured by Blauwens (Blauwens, 2002, p. 78)(currency of EUR and USD assumed equal at that time), and for Russia and Iran the amounts are generated by comparison with Europe.

2.1.3 Sea transport

For the sea transport in addition to the capital costs, the operational costs are divided into maintenance, operating, voyage, and the cargo handling costs. The approach of calculating unit cost per annum is: (Stopford, 1997, p. 154).

$$C = (OC+PM+VC+CHC+K) / dwt$$

Where:
- C = cost per dwt per annum
- OC = operating cost per annum
- PM = periodic maintenance provision per annum
- VC = voyage cost per annum

CHC = cargo handling cost per annum

K = capital cost per annum

dwt = ship deadweight

After calculating the cost of 1 dwt per year, the daily cost of cargo unit can be defined as:

? (TEU slot daily cost) = C*15 / 365

1 TEU = 15 tones in average

Now, by multiplying ? to the time of transportation, the cost of sea transport section of the voyage can be achieved.

Drewry shipping consultant has another approach to calculate the short run ship costs. It divides the costs in 3 groups: the capital cost, the operating cost and the voyage cost, which is similar to the Stopford approach, but the periodical maintenance is hidden in the operating cost and the cargo handling costs hidden in the voyage cost. The unit cost for a container ship in this approach will be:

? = (K+Oc+Vc) / TEU

Where: K = Capital cost per day

Oc = Operating cost per day

Vc = Voyage cost per day

The capital cost is the cost of ship acquisition; the operating cost is included the manning or crewing, the insurance, the repair and maintenance, the stores and supplies, and the management and administration costs. The manning cost itself is divided by the two kinds of costs, direct and indirect costs. The direct costs are the wage, the travel, on board victualling, the training and union fee; the indirect costs include the recruitment/selection and processing, the medical and drug/alcohol tests, the welfare/social dues, the communication/bank charges, the crew accident insurance cover, the sick pay, the standby pay, the port expenses, and the agency fee. The insurance also has a wide range of costs including the hall & machinery, the war risks, the P&I, FD&D, COFR/oil pollution surcharges, the war, and strikes insurance costs. The maintenance and repair is divided into the scheduled repairs, the survey required, and the unscheduled repairs. The store, spare and supplies like the lubricating oil and paints needed to logistics activities and the investment. The management and administration costs include the technical ship management and

the commercial ship management, the ship registry and some other overheads that generate costs for ships. Similarly the voyage cost includes bunkers cost, port dues and the other port charges and canal tolls (Drewry, 2002). Finally, the ship cost equation will be:

Total cost per TEU slot per day = (K+Man+Ins+R&M+S+OH+Bu+PD)/TEU

Where: K = Capital cost per day

Man = Manning cost per day

Ins = Insurance cost per day

R&M = Repair and Maintenance per day

S = Store and supplies cost per day

OH = Overhead per day

Bu= Bunkering cost per day

PD = Port and canal dues

The total sea transport cost is the terminal handling cost plus the sea transport cost.

There are 3 links of sea transport on the routes: Singapore to Hamburg, Singapore to Bandar Abbas, and Amir Abad or Anzali Port to Astrakhan. **Table** 3 shows the cost calculation of each one:

Table 3: cost calculation for container ships

sea transport **All amount in US$ Per day**

TEU	**capital cost**	**operation costs**					**voyage cost**			**cost per day per TEU**				
ship size	**capital**	**manning**	**insurance**	**R & M**	**supplies**	**overhead**	**bunkering**	**Suez charge**	**Port dues**	**sum**	**total**	**Bc.**	**Ec.**	?
4000	17000	1842	740	2330	1781	4739	17000	9810	7000	62242	16	1.1	1	17
2000	11000	1600	614	1836	1671	3344	8670	0	5000	33735	17	1.2	1.2	24
300	2466	1400	422	411	548	1049	2040	0	1000	9336	31	1.3	1.2	49

Source: Drewry, 2002 & Drewry, 1997 , Author

The bigger ships for travelling between S/E Asia and Europe (4000 TEU) are recruited, and the medium size ships for travelling between S/E Asia and Persian Gulf (2000TEU) employed, but for the Caspian Sea there is a lack of depth for large vessels and small feeders (300 TEU) can only be used in that sea. The amounts are

extracted from Drewry consultant group researches (Drewry, 2002), (Drewry, 1997). For R & M costs only the bulk carrier amounts were available. Therefore the same amounts are used for container ships. Overhead calculated as 20% of total operating costs.

2.1.4 Rail transport

The railway companies, which benefit from monopoly in most countries, use different approaches to charge their customers. Charges may based on the selling of the train space to the customers in exchange for a trainload tariff, or the selling of the wagon space for a wagonload tariff, or the selling of the train paths to exchange track access. Organization for Railways Cooperation (OSJD) sat an approach for the members to harmonize the tariffs but still there is no unique system between the countries involved. (ESCAP, 2001, p. 67).

2.1.4.1 Infrastructure

Building a railway system needs huge amounts of investment as infrastructure; the costs of that investment are categorized in 3 groups: (Ott, 2004, p. 3)

1- The cost of capital (depreciation and interest on fixed capital).
2- The costs for running (operation and service) the infrastructure.
3- The costs for maintenance of the infrastructure.

Figure 9 shows the comparison between the costs of rail and road infrastructure for some routes in Europe:

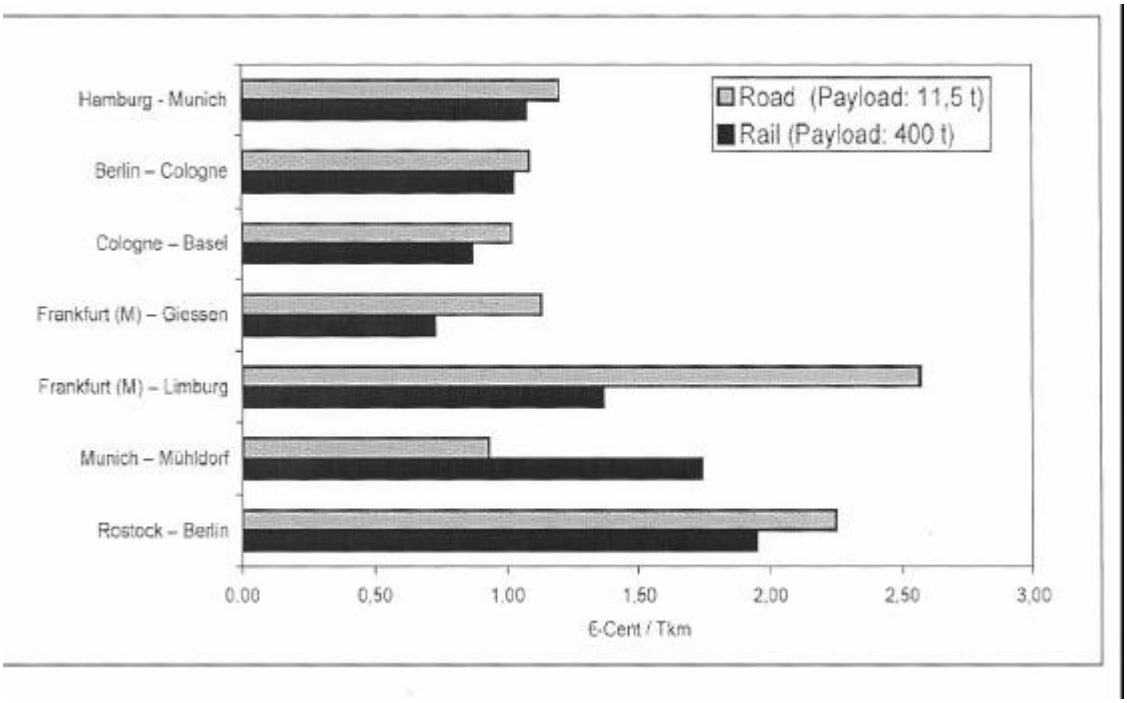

Figure **9:** The infrastructure cost comparison between rail and road

Source: *(Ott, 2004, p. 9)*

As Figure 9 shows rail looks cheaper than road in most cases.

2.1.4.2 Total railway cost

As an approach for calculating total cost in the railway transport, the cost resources are considered as 3 types:

Transport operation costs, which is day-to-day costs of operating the railway system.

Community costs, such as the freight revenue, supplements, capital grants, tax exception, and the opportunity cost of assets, which are incurred because of existence of the railroad services.

External costs, which are difficult to quantify, are imposed to the third party as a result of the railway system, like the noise, air pollution, traffic congestion and accident costs. In most countries the freight revenues fail to cover the railway system costs; therefore, governments pay subsidies to them. Calculation of the exact costs is very difficult because of the complexity of transport. There is no one to

one correspondence between services and costs. To have this correspondence between the services and the costs, 4 categories of costs are introduced as:

1- **Avoidable costs**, which uniquely associated with a particular service, that if the service is not offered, the costs could be avoided.
2- **Common costs** are the shared costs between two or more services, which occur when the services are under control, and the costs are divided between them, corresponding with their weight. For example, if 50 percent of the gross ton-kilometre of a service belongs to one commodity, some costs like the fuel cost can be associated with that commodity by 50%.
3- **Joint costs** are similar to the common costs, but they do not vary with the quantity or proportion of ton-kilometres of commodities, like the cost of signal maintenance that do not vary with the traffic load.
4- **Fully distributed costs** are attributed in the various services like the capital cost for railroad. (Button, 1985, p. 139).

This research is tried to identify the transport cost per ton-kilometre of cargo, but the cost is not the same in all countries, because of the differences in the transport policy, labour and other costs. Table 4 shows the differences in three regions on the routes:

Table 4: rail transport cost in the countries or regions per TEU

Rail Transport **US$ per km**

	Avo. Cost	**Bc.**	**Ec.**	**total**
Iran	0.2	1.3	1.2	0.312
Russia	0.2	1.3	1.2	0.312
Europe	0.5	1	1	0.5

Source: Author

Bc. = Balance Factor

Ec. = Economic of scale Factor

The governments subsidize the rail transport for several reasons; therefore in this research only avoidable costs such as the marginal price are used for comparison.

By using the railway companies' tariffs from Hamburg and Iran the avoidable costs per kilometre are generated.

2.1.5 Terminal Handling Cost

Using the different types of transport means in the voyage causes another cost for the handling of cargo between these different means, which occurs in the ports when cargo is handed over to the land transport from the sea transport. On the borders when the vehicle standards are not the same in the two countries, or change between the rail and the road transport in some terminals there are the same situation. THC (Terminal Handling Cost) term used in this research for the all kind of exchange costs of the cargo between the sea and the rail, the sea and the road, the road and the rail, the rail and the road, or the rail and the rail in case of difference in the gauges size in the borders. THC will be added to whole transport cost as a lump sum when it is needed.

2.2 Time cost

"Time is money", is not because time as an individual object has value. Time value is derived by the value added that is earned for the user to produce more during the saved time or to use that time for some other activities. But in reality the flow of time cannot be replaced by anything, and the time is irretrievable in human life, or from another point of view it belongs to man's limited resources. (Tarski, 1987, p. 148).

The cargo capital is very sensitive to the transit time, and any delay in delivery makes some losses for the cargo owner. Shippers tied lots of money on their cargos, and if the cargo stay idle during the trade, the opportunity cost of this money can be calculated as the time cost or delay cost; therefore, the delivery time cost must be monitored in the total cost of transport by using the opportunity cost concept (Ma, 2003). The opportunity cost of that capital is the amount of benefit that could be achieved from new trade by the shipper during that lost time. If there is no other opportunity, time value can be measured by the market, financial or bank discount rate of the purchase price of cargo. Most shippers use loans for import

cargo. The interest of these loans can be use as the base of time value. Time cost or time value from the cargo owner's point of view is:

$$\text{Time cost} = V[(1+\rho)^{D} - 1]$$

Where:

ρ= Interest daily rate

V= Cargo purchase price

D = total transit time in days

2.3 Risk cost

The risk of pilferage, loss or damage of cargo during the voyage will affect the insurance cost as well as needs to increase the security measures can generate more costs for the cargo owners, and shipping companies. The insurance companies will ask a higher rate for the unsafe or unreliable routes, and the shippers need to use more security means like locks, recruiting guards and tracking systems for their cargo. Railways, trucks, and shipping companies need to use better security systems, to pass the cargo safe and sound. These surcharges must be shown in the money outlay as well.

From the cargo owner's point of view the risks are categorized in 3 levels:

2.3.1 Operational and technical risks:

Lack of experience in transport or unsafe transport practices by drivers can increase the accidents, loss or damages of cargos during the voyage. Substandard equipment, untrained manpower or bad documentation can also result in damage. Standardization in organizing the transport schedule, using the standard equipment and recruiting well-trained labour, and installing the IT system can reduce this kind of risks. Consequently, the cost of risk will decline too.

2.3.2 Commercial and financial risks:

Fraud, lack of suitable documentation norm and lack of authorisation for players on the route and lack of supervision can produce losses for shippers. Some times unrealistic or obsolete information or absence of reliable information can result in

losses too. Installation of a responsible authority to organizing transport activities in the route and authorizing only fulfil companies, preparing reliable information and supervising the whole chain of activities without reducing competition can increase the safety of transport and reduce this kind of risks.

2.3.3 Political risks:

The security of cargo during the voyage is not achievable unless the government of the country becomes stable and manages to maintain the roads, rails, waterways and other premises secure. This kind of risk not only endangers the cargo from theft or damage, but also endangers lives of workers involved in transport. The value of losses derived from this kind of risks is difficult to calculate.

Generally speaking, the cost of security must be added to the other costs, but measuring the exact security cost is very difficult. May be the use of a factor for security to imply to the total cost is another solution. However, the best way could be the calculation of probability of damage and multiply it by the average losses, but for this calculation the statistics of pilferage, loss or damage of cargo or lost or injury of lives on a route for a wide range of time is needed. Statistics can be retrieved from claims in recent years too.

$$\text{Risk cost} = P^* V$$

P = probability of damage

V = cargo purchase price

2.4 Conclusions

The hour coefficient and kilometre coefficient are useful parameters for calculation of the road transport cost, but some assumptions should use for simplification, such as that the company has only one trailer per each truck (Blauwens, 2002, p. 76). For better alignment multiplying some other coefficients to affect the balance of cargo and economies of scale is needed. (Bc. and Ec. Factors).

This research uses the avoidable costs for the rail transport section as the floor tariff and multiplies two additional coefficients to correct the results for cargo balance and economies of scale as well.

For the sea transport section using the Drewry approach to calculate the unit cost is suitable.

Road transport cost = (Hour * Hc + Kilometre * Kc) * Bc * Esc

Rail transport cost = (Avoidable costs) * Bc * Ec.

Sea transport cost = ? * Days

Where :

Hc = Hour coefficient

Kc = Kilometre coefficient

Bc. = Balance factor

Ec. = Economies of scale factor

? = TEU slot's daily cost

Chapter 3

Comparison of two routes

3.1 Total cost

According to the last chapter the total cost includes transport cost (money outlay), time cost and risk cost. The transport cost from continent A to the market M is equal by:

$$C_1(n) = a * l_{An} + p_n + \Sigma_j b_{nMj} * l_{nMj}$$

Where:

a = Ship cost per km per slot TEU

l_{An} = distance from the region A to the n^{th} port

p_n = port charge at n^{th} port

b_{nMj}= unit cost transport for mode j per container per km

l_{nMj} = inland transport distance

The Time cost is: $C_2= V_i[(1+ r)^{Dn} – 1]$

Where:

$D_n= (l_{An}/24S_s) + H_n+ \Sigma (l_{nMj}/24S_j)$

S_s= Sea transport speed

S_j= Domestic transportation speed

H_n= Port n^{th} dwelling time

V_i= Value of each container

r = Daily unit cost of capital

In the D_n equation the first parentheses is the time spent at sea; the second parentheses is the time in port and the last one is the domestic transport time. All dimensions are in days.(Lou, 2002, p. 3). For sea transport the unit cost that is used in this research is the cost of a TEU slot per day instead of TEU slot per kilometre with the average speed of 14 knots, and the risk cost is:

$$C_3 = P_i * V_i$$

Where: P_i = probability of loss or damage

Finally the total cost will be:

$$TC_i(n) = ? * D_{An} + p_n + \Sigma_j b_{nMj} * l_{nMj} + V_i[(1+r)^{Dn} - 1] + P_i * V_i$$

Where: ? = TEU slot's daily cost at sea

D_{An} = time at sea, days

This calculation would be done for every route from continent A to market M for comparison. The values are available from the last chapter. They are calculated by using some consultant references like Dewory, or generated with comparison by real amounts in the transport market.

3.1.1 Outlay cost

As the cost calculated in last chapter, the unit cost of sea transport according to the size of the ships is:

Table 5: Unit transport cost at sea US$ per day per slot TEU

US$/ TEU	**per day per slot**
Ship size	**?**
4000 TEU	17
2000 TEU	24
300 TEU	49

Source: Author

4000 TEU ships are used in S/E Asia to Europe via the Suez Canal; 2000 TEUs are employed in S/E Asia to Bandar Abbas, and 300 TEUs are considered as the size of

the ships in the Caspian Sea. For port charges and handling costs in ports US$ 540 is assumed for BAF and THC cost.
For road and rail the amounts achieved in the last chapter are used to calculate the total outlay costs.

3.1.2 Time cost

The cargo is considered as a high value cargo; for a practical example a TEU container including 150 packed computer components with a purchase price of US$800 each is assumed. The annual discount rate for calculating the opportunity cost of cargo is considered as 10%. Finally, the daily unit rate of interest is:

$$?= \sqrt[365]{(1+10\%)} - 1 = 0.026\% \text{ per day}$$

The days include voyage time, time in port and time at borders to pass customs. In this research, time in ports in case of hand over cargo to another means of transport assumes 2 days and time to pass each border assumes 1 day.

3.1.3 Risk cost

The probability of loss or damage on the routes is not published normally by the administrations involved, but insurance companies use the relatively comparable premium on a route with this probability. This premium depends on safety, security and political and financial stability of the countries. The premium is a fraction of the cost that depends on cargo value, journey length and the level of risk as well, and it varies between less than 0.2% for very safe routes (European Commission, 2001) and never exceed from 1% of load value on dangerous routes. (The Canadian Trade Commissioner Service, 2001).

The Suez Canal and European Railways are very safe, and in this research the risk cost of that route is calculated by 0.2% of the cargo purchase price. Iran and Russia are the main countries in the North-South Corridor are relatively safe countries and

in this research risk cost is assumed to vary from 0.4 to 0.6% of the cargo purchase price related to the means of transport.

3.2 Total Land Bridge

For the first step the total land bridge can be used in the North-South Corridor. The final destination of the cargo to be assumed the north coasts of Europe or Scandinavian countries, and the user of the North-South Corridor must pass all the land bridges of Iran, the Caspian Sea, Russia, (some other central Asian countries in case of using direct delivery by rail or road), Belarus or Ukraine, Poland, and Germany to deliver the cargo in Hamburg, or Iran, Russia, Finland to deliver the cargo in Helsinki. However the user of the Suez Canal can deliver the cargo to destination by using only sea transport.

3.2.1 Singapore to Hamburg

When the Suez Canal is used for direct transport cargo between Singapore and Hamburg, the cost will definitely be much less than using the North-South Corridor as a land bridge. On the land bridge, 3 times double handling increases the cost, not only in case of using the Caspian Sea but also if rail for the whole voyage on the land bridge is used, because there are different in rail gauge size between Iranian and Russian railways and between Russian and European Railways. This is time consuming and costly. The time can be longer than expected because at least 3 borders have to be passed. On the borders vehicles need at least 3 days for documentation in rail or road transport in an optimistic situation. Table 6 shows the total cost for using each possibility:

Table 6: Cost comparison between 4 possibilities by different means of transport from Singapore to Hamburg in US$ per TEU

	Km	Days	US$	**Time cost**	**Damage pro.**	**Risk cost**	**THC**	**TOTAL**
N/S Corridor (Sea, Rail, Caspian)	Distance	time	total outlay		0.50%	600		600
Singapore to Bandar Abbas	5368	10.5	795	328				1373
Bandar Abbas to Amir Abad	1743	4.7	544	147			250	941
Amir Abad to Astarakhan	1400	4	734	125			250	1109
Astrakhan to Hamburg	3726	7.3	1163	228			250	1390
Sum	12237	26.5	3236	828		600	750	**5413**

	Km	Days	US$	**Time cost**	**Damage pro.**	**Risk cost**	**THC**	**TOTAL**
Suez Route (total sea)	Distance	time	total outlay		0.20%	240		240
Singapoure to Hamburg	13607	27	1002	845				1847
Sum	13607	27	1002	845		240	0	**2087**

	Km	Days	US$	**Time cost**	**Damage pro.**	**Risk cost**	**THC**	**TOTAL**
N/S Corridor (sea, road, Caspian)	Distance	time	total outlay		0.60%	720		720
Singapore to Bandar Abbas	5368	10.5	795	328				1373
Bandar Abbas to Amir Abad	1743	4	611	125			250	986
Amir Abad to Astarakhan	1400	4	734	125			250	1109
Astrakhan to Hamburg	3726	6.3	1306	197			250	1503
Sum	12237	24.8	3447	774		720	750	**5691**

	Km	Days	US$	**Time cost**	**Damage pro.**	**Risk cost**	**THC**	**TOTAL**
N/S Corridor(sea, rail, Direct)	Distance	time	total outlay		0.40%	480		480
Singapore to Bandar Abbas	5368	10.5	795	328				1373
Bandar Abbas to Djolfa	2325	5.5	725	172			250	1147
Djolfa to Hamburg	4776	10.5	1490	328			250	1818
Sum	12469	26.5	3011	828		480	500	**4818**

Source: Author, Bartholomew Ltd. & Time Books 1999 & Lloyd's Register-Fairplay, 2002

The average speed is 14 knots including port around times for calculating sea transport times. The average speed used for rail and road is shown in Table 7. The speed for road is 30% more than to rail, which is reasonable.

Table 7: speed including idle times km/h

Speed km/h	**Rail**	**Road**
Iran	27.3	35.5
Russia and EU	36.4	47.3

Source: ESCAP, 2001, Author

Terminal handling for handover cargo to the next means of transport is assumed to be roughly US$250. THC and BAF costs are included in sea transport outlay cost.

At the moment the freight rate for Asia to Europe is around US$1700 per TEU, including BAF and THC, but there is some fluctuation. The average amount of freight for this route from 1993 to now according to Figure 9 is around US$1400. The real freight rate is different from the calculation in this research. This is because of the following:

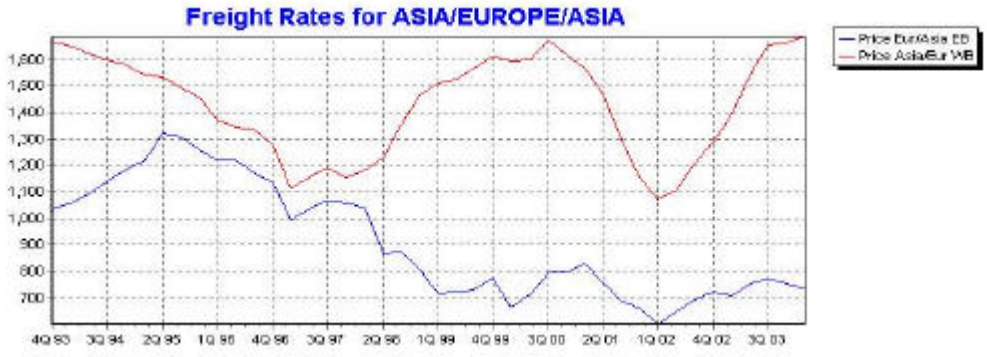

Figure 10: Freight rates for Asia to Europe and Europe to Asia

Source: http://www.ci-online.co.uk/

1- Shipping companies keep some margin for cases of any change in cargo flow like seasonal decrease or any unpredicted cost.
2- The pricing mechanism in shipping business is different by cost calculation. The price is a function of demand and supply rather than expenditures in an operation or voyage; therefore, the market can affect freight every day.

The railway tariff and road transport are inline with the calculations in this research, for example the freight of rail transport between Bandar Abass and Amir Abad in Iran in the freight book of 2002 of RAI (Iranian Railway Company) for transporting a full laden 20 footer container including returning the empty is US$571.5 (IR-Rial 4,572,000), (Iran, Ministry of Road and Transport, 2001). The calculation in Table 6 shows US$544.

Road transport tariffs in Iran and Russia are very negotiable and there is similarity between reality and the cost calculation of this research.

Table 8 compares the costs between 3 possibilities: transport via the North-South Corridor and the use of the Caspian Sea, transport via the North-South Corridor and all the way by rail (via Djolfa) and all sea transport via the Suez Canal:

Table 8: Cost comparison between 3 possibilities Singapore to Hamburg in US$

Singapore to Hamburg	Money outlay	distance	Days	Total cost
Via Caspian Sea	3236	12237	26.5	5413
Via Djolfa	3011	12469	26.5	4818
Via Suez Canal	1002	13600	27	2087

Source: Author

As Table 8 shows, using the land bridge for the assumed cargo price and risk probability is not reasonable.

3.2.2 Bombay to Hamburg

If the total land bridge is used for transportation between Bombay and Hamburg the situation could be different. The assumptions are similar to the last case. According to time saving, the land bridge can save a day, but still according to the total cost, the Suez Canal is still reasonable to use:

Table 9: Cost comparison between 3 possibilities Bombay to Hamburg in US$

Bombay to Hamburg	Money outlay	distance	Days	Total cost
Via Caspian Sea	3066	8556	19.5	5023
Via Djolfa	2841	8788	19.5	4428
Via Suez Canal	891	10482	20.5	1772

Source: Author

3.2.3 Singapore to Helsinki

Another option to access the north of Europe is Helsinki that is used by North-South Corridor as well. Distances and time calculation for that route on the land bridge has been calculated by ESCAP (ESCAP, 2001). The results are similar to the last case:

Table 10: Cost comparison between 3 possibilities for Singapore to Helsinki in US$

Singapore to Helsinki	Money outlay	distance	Days	Total cost
Via Caspian Sea	3027	11570	22.7	5086
Via Djolfa	2823	11869	22.8	4515
Via Suez Canal	1045	14964	29.5	2209

Source: Author

3.2.4 Bombay to Helsinki

Administrations involved in the North-South Corridor are encouraged to use this route for transport cargo between Bombay to Helsinki, but the calculation shows that using the Suez Canal is more efficient in case of total land bridge use.

Table 11: Cost comparison between 3 possibilities for Bombay to Helsinki in US$

Bombay to Helsinki	Money outlay	distance	Days	Total cost
Via Caspian Sea	2857	7889	15.7	4697
Via Djolfa	2653	8188	15.8	4127
Via Suez Canal	1040	14964	29.2	2194

Source: Author

In this case time is saved in the corridor but total cost is still too much in comparison to the Suez Canal.

3.3 Mini Bridge

Destination of cargos is not the northern coast of Europe in many cases. The East European countries, CIS land Locked countries and even central Europe is vast markets for South East Asian products. Therefore, cargo after unloading in Hamburg or Helsinki has to be transported on land in Europe when the Suez Canal Route is used. On the other hand, the land transport in the North-South Corridor will be shorter if the destination is located inland of Europe. The situation of comparability of costs on both sides will change if the destination of the cargo is located somewhere between the northern coast of Caspian Sea and northern European ports.

Eventually there are some points in between that the cost of transport in use of both routes becomes equal. These points are shown by Xs in this research, and Equi-Cost Curves are the location of these points, that need to spend the same amount of money to transport cargo from the same origin via different routes to them. Equi-Cost Curves are borders between coverage area of hinterlands of Astrakhan and Hamburg or between hinterlands of Astrakhan and Helsinki or between Djolfa as a connecting point and Hamburg or Helsinki. In the other way between Hamburg and Helsinki as the northern European ports from one side and Astrakhan and Djolfa as the connecting points in south from the other side, the Equi-Cost Curves divide Eastern Europe and Russia lands to coverage area of the North-South Corridor and the Suez Canal Route or Northern European Ports Route.

3.3.1 Equi-Cost curves between Singapore and Hamburg

Three possibilities are investigated for transport cargo from Singapore toward Hamburg via the North-South Corridor: Caspian Sea and rail, Caspian Sea and road, and direct delivery by rail via Djolfa. From the other hand there are two possibilities for that transport via Suez Canal after Hamburg: using rail or road. For keeping a standard in comparison only rail will be used for both sides and two X points are achievable, one between Astrakhan and Hamburg in case of using the Caspian Sea, another one between Djolfa and Hamburg, in case of direct delivery by rail from Bandar Abbas to Hamburg.

For road, the way of comparison will be same but the curves are different.

The X for Astrakhan to Hamburg by using the Caspian Sea and railway is calculated by Excel functions as Table 12 shows.

Table 12: Calculating Equi-Cost point X1 for Singapore to Hamburg via Caspian Sea

N/S Corridor(sea, rail)	Km	Days	US$	**Time cost**	**Damage pro.**	**Risk cost**	**THC**	**TOTAL**
	Distance	time	total outlay		0.50%	600		600
Singapore to Bandar Abbas	5368	10.5	795	328			250	1373
Bandar Abbas to Amir Abad	1743	4.7	544	147			250	941
Amir Abad to Astarakhan	1400	4	734	125			0	859
Astrakhan to X	**1095**	1.3	342	39				381
Sum	9606	20	2415	639		600	500	4153

Suez Route (sea, rail)	Km	Days	US$	**Time cost**	**Damage pro.**	**Risk cost**	**THC**	**TOTAL**
	Distance	time	total outlay		0.20%	240		240
Singapoure to Hamburg	13607	27	1002	845			250	2097
Hamburg to X	2631	8.0	1316	250			250	1816
Sum	16238	35	2318	1095		240	500	4153

Source: Author

X1 is located 1095 km from Astrakhan towards Hamburg. Transit time for Astrakhan toward the north is calculated by the speed of the train because it does not pass any border. However from Hamburg to Russia 2 days for time in port and 3 days for passing 3 borders of Germany, Poland, and Belarus needs to be added, because X1 is located in Russia land escape.

If direct delivery by rail is used from Bandar Abbas to Hamburg via Djolfa, the X2 can be calculated as shown in table 13.

Table 13: Calculating Equi-Cost X2 point for Singapore to Hamburg via Djolfa

Suez Route(sea, rail)	Km	Days	US$	**Time cost**	**Damage pro.**	**Risk cost**	**THC**	**TOTAL**
	Distance	time	total outlay		0.20%	240		240
Singapoure to Hamburg	13607	27	1002	845			250	2097
Hamburg to X	2241	7.6	1120	236			250	1607
Sum	15848	35	2123	1081		240	500	3944

N/S Corridor (sea, rail)	Km	Days	US$	**Time cost**	**Damage pro.**	**Risk cost**	**THC**	**TOTAL**
	Distance	time	total outlay		0.40%	480		480
Singapore to Bandar Abbas	5368	10.5	795	328			250	1373
Bandar Abbas to Djolfa	2325	5.5	725	172			250	1147
Djolfa to x	**2535**	4.9	791	153				944
Sum	10228	21	2311	653		480	500	3944

Source: Author

X2 is located 2535 km from Djolfa towards Hamburg. Two borders in Azerbaijan and Armenia need 2 days to pass, but from Hamburg 2 days is needed for time in port and 3 days to pass 3 East European country borders.

The fist Equi-Cost curves are sketched by using these points in Map 1.

Map 1: Equi-Cost Curves as the borders between coverage areas of the N/S Corridor and the Suez Canal (northern European ports) when Singapore is the origin of cargo and Hamburg use as the northern European port used by the Suez Canal Route.

X1 is the limit point, in case of using the Caspian Sea in the N/S Corridor.

X2 is the limit point, in case of direct delivery by rail from Bandar Abbas via Djolfa in the N/S Corridor.

Source: Author

3.3.2 Equi-Cost curves between Singapore and Helsinki

The same condition is applicable for Helsinki Port. X3 and X4 will be the points between Astrakhan-Helsinki and Djolfa -Helsinki shown in Map 2.

Table 14: Calculating Equi-Cost point X3 for Singapore to Helsinki via Caspian Sea

N/S Corridor (sea, rail)	Km	Days	US$	**Time cost**	**Damage pro.**	**Risk cost**	**THC**	**TOTAL**
	Distance	time	total outlay		0.50%	600		600
Singapore to Bandar Abbas	5368	10.5	795	328				1373
Bandar Abbas to Amir Abad	1743	4.7	544	147			250	941
Amir Abad to Astarakhan	1400	4	734	125			250	1109
Astrakhan to X	**763**	0.9	238	27			250	265
Sum	9274	20	2311	627		600	750	4288

Suez Route (sea, rail)	Km	Days	US$	**Time cost**	**Damage pro.**	**Risk cost**	**THC**	**TOTAL**
	Distance	time	total outlay		0.20%	240		240
Singapore to Helsinki	14964	29.5	1045	924			250	2219
Helsinki to X	2296	5.6	1653	176				1829
Sum	17260	35	2698	1100		240	250	4288

Source: Author

X3 is located 763 km from Astrakhan towards Helsinki. The same conditions are applicable as the last calculations for X1, and X2, but Helsinki will pass only 1 border to enter Russia.

For direct transport from Bandar Abbas to Helsinki via Djolfa, the following table calculates X4.

Table 15: Calculating Equi-Cost point X4 for Singapore to Helsinki via Djolfa

Suez Route (sea, rail)	Km	Days	US$	**Time cost**	**Damage pro.**	**Risk cost**	**THC**	**TOTAL**
	Distance	time	total outlay		0.20%	240		240
Singapoure to Helsinki	14964	29.5	1045	924			250	2219
Helsinki to X	1778	5.0	1280	157				1438
Sum	16742	35	2325	1081		240	250	3896

N/S Corridor (sea, rail)	Km	Days	US$	**Time cost**	**Damage pro.**	**Risk cost**	**THC**	**TOTAL**
	Distance	time	total outlay		0.40%	480		480
Singapore to Bandar Abbas	5368	10.5	795	328				1373
Bandar Abbas to Djolfa	2325	5.5	725	172			250	1147
Djolfa to X	**2398**	4.7	748	148			250	896
Sum	10091	21	2269	648		480	500	3896

Source: Author

X4 is located 2,398 km from Djolfa and still the North-South Corridor is reasonable to use according to the Suez Canal Route to access CIS countries up to 2,398 km from Djolfa. Map 2 shows the related Equi-Cost Curves.

Map 2: Equi-Cost Curves as the borders between coverage areas of the N/S Corridor and the Suez Canal when Singapore is the origin of cargo and Helsinki use as the northern European port used by the Suez Canal Route.

X3 is the limit point, in case of using the Caspian Sea in the N/S Corridor.

X4 is the limit point, in case of direct delivery by rail from Bandar Abbas via Djolfa in the N/S Corridor.

Source: Author

3.3.3 Equi-Cost Curves between Bombay and Hamburg

By applying the same calculation for transport cargo between Bombay to Europe two other EQUI-Cost curves are generated.

Table 16: Calculating Equi-Cost point X5 for Bombay to Hamburg via Caspian Sea

N/S Corridor(sea, rail)	Km	Days	US$	**Time cost**	**Damage pro.**	**Risk cost**	**THC**	**TOTAL**
	Distance	time	total outlay		0.50%	600		600
Bombay to Bandar Abbas	1687	3.5	625	109			250	984
Bandar Abbas to Amir Abad	1743	4.7	544	147			250	941
Amir Abad to Astarakhan	1400	4	734	125				859
Astrakhan to X	**1178**	1.3	368	42				410
Sum	6008	14	2271	423		600	500	3793

Suez Route (sea, rail)	Km	Days	US$	**Time cost**	**Damage pro.**	**Risk cost**	**THC**	**TOTAL**
	Distance	time	total outlay		0.20%	240		240
Bombay to hamburg	10482	20.5	891	641			250	1782
Hamburg to X	2548	7.9	1274	247			250	1771
Sum	13030	28	2165	888		240	500	3793

Source: Author

X5 is located 1178 km after Astrakhan toward Hamburg. In comparison with the case of Singapore to Hamburg the coverage area of the North-South Corridor is more expanded. In case of direct rail transport from Bandar Abbas to Hamburg X6 is calculated in Table 17:

Table 17: Calculating Equi-Cost point X6 for Bombay to Hamburg via Djolfa

Suez Route (sea, rail)	Km	Days	US$	**Time cost**	**Damage pro.**	**Risk cost**	**THC**	**TOTAL**
	Distance	time	total outlay		0.20%	240		240
Bombay to hamburg	10482	20.5	891	641			250	1782
Hamburg to X	2158	7.5	1079	233			250	1562
Sum	12640	28	1970	874		240	500	3584

N/S Corridor (sea, rail)	Km	Days	US$	**Time cost**	**Damage pro.**	**Risk cost**	**THC**	**TOTAL**
	Distance	time	total outlay		0.40%	480		480
Bombay to Bandar Abbas	1687	3.5	625	109			250	984
Bandar Abbas to Djolfa	2325	5.5	725	172			250	1147
Djolfa to X	**2618**	5.0	817	156				973
Sum	6630	14	2167	437		480	500	3584

Source: Author

X6=2618 km from Djolfa toward Hamburg is another point on curve.

Map 3 shows the related Equi-Cost curves.

Map 3: Equi-Cost Curves as the borders between coverage areas of the N/S Corridor and the Suez Canal when Bombay is the origin of cargo and Hamburg use as the northern European port used by the Suez Canal Route.

X5 is the limit point, in case of using the Caspian Sea in the N/S Corridor.

X6 is the limit point, in case of direct delivery by rail from Bandar Abbas via Djolfa in the N/S Corridor.

Source: Author

3.3.4 Equi-Cost Curves between Bombay and Helsinki

The same calculation can generate other Equi-Cost curves for transport between Bombay to Helsinki:

Table 18: Calculating Equi-Cost point X7 for Bombay to Helsinki via Caspian Sea

N/S Corridor (sea, rail)	Km	Days	US$	**Time cost**	**Damage pro.**	**Risk cost**	**THC**	**TOTAL**
	Distance	time	total outlay		0.50%	600		600
Bombay to Bandar Abbas	1687	3.5	625	109				984
Bandar Abbas to Amir Abad	1743	4.7	544	147			250	941
Amir Abad to Astarakhan	1400	4	734	125			250	1109
Astrakhan to x	**614**	0.7	192	22			250	214
Sum	5444	13	2095	403		600	750	3847

Suez Route (sea, rail)	Km	Days	US$	**Time cost**	**Damage pro.**	**Risk cost**	**THC**	**TOTAL**
	Distance	time	total outlay		0.20%	240		240
Bombay to Helsinki	14964	29.2	1040	914			250	2204
Helsinki to X	2445	5.8	1222	181				1403
Sum	17409	35	2262	1095		240	250	3847

Source: Author

X7 will be 614 km farther than Astrakhan and:

Table 19: Calculating Equi-Cost point X8 for Bombay to Helsinki via Djolfa

Suez Route (sea, rail)	Km	Days	US$	**Time cost**	**Damage pro.**	**Risk cost**	**THC**	**TOTAL**
	Distance	time	total outlay		0.20%	240		240
Bombay to Helsinki	14964	29.2	1040	914			250	2204
Helsinki to X	1798	5.1	899	158				1057
Sum	16762	34	1939	1072		240	250	3501
N/S Corridor (sea, rail)	Km	Days	US$	**Time cost**	**Damage pro.**	**Risk cost**	**THC**	**TOTAL**
	Distance	time	total outlay		0.40%	480		480
Bombay to Bandar Abbas	1687	3.5	625	109				984
Bandar Abbas to Djolfa	2325	5.5	725	172			250	1147
Djolfa to x	**2378**	4.7	742	147			250	889
Sum	6390	14	2092	428		480	500	3501

Source: Author

X8 is located in 2378 km from Djolfa. Map 4 shows the Equi-Cost Curves associated with these points.

Map 4: Equi-Cost Curves as the borders between coverage areas of the N/S Corridor and the Suez Canal when Bombay is the origin of cargo and Helsinki use as the northern European port used by the Suez Canal Route.

X7 is the limit point, in case of using the Caspian Sea in the N/S Corridor.

X8 is the limit point, in case of direct delivery by rail from Bandar Abbas via Djolfa in the N/S Corridor.

Source: Author

In the following table the percentage of distance between ports in north of Europe and connection points in south of Russia are listed.

Table 20: X1 to X8 and distances percentage to Hamburg and Helsinki

Route	from Astrakhan	from Djolfa	Astrakhan to End	Djolfa to End	perc. From Astrakhan	Perc. From Djolfa
Singapore Hambourg X1,X2	**1095**	**2535**	3726	4776	29%	53%
Singapore Helsinki X3,X4	**763**	**2398**	3059	4176	25%	57%
Bombay Hamburg X5,X6	**1178**	**2618**	3726	4776	32%	55%
Bombay Helsinki X7,X8	**614**	**2378**	3059	4176	20%	57%

Source: Author

As shown in Table 20, when the Hamburg uses as the distribution centre for the Suez Canal Route, change the origin from Singapore to Bombay increases the coverage area of the N/S Corridor, because saving in sea transport in the N/S Corridor in this case is greater than saving in the Suez Canal. Whereas, Helsinki as the distribution centre for northern Europe has inverse effect, because the saving in the Suez Canal Route is more considerable than the N/S Corridor (less idle times because less borders passing and bigger part of costs is related to the sea transport).

3.4 Other option

The most important option for change position of curves is possibility of transport cargo from S/E Asia via the Black Sea. At the moment ports Poti and Batumi of Georgia are able to receive feeder container ships and connected to the local railway. For making a comparison between the North-South Corridor and the Suez Canal and the Black Sea ports possibility to cover south and west part of Russia and CIS countries, the transport via a Mediterranean hub port to Poti and using railway of Georgia is investigated. By the same total cost of transport to X1 via Astrakhan the maximum economical distance from Poti will be:

Table 21: Calculation of economical distance from Poti via Black Sea

Suez Route (sea, rail)	Km	Days	US$	**Time cost**	**Damage pro.**	**Risk cost**	**THC**	**TOTAL**
	Distance	time	total outlay		0.40%	480		480
Singapoure to Malta	13607	18.5	857	608			250	1715
Malta to Poti	2293	6.5	856	214			250	1326
potti to X	**993**	4.1	496	136			0	632
Sum	16893	29	2209	958		480	500	4153

Source: Author

993 km from Poti can cover the Georgia, Azerbaijan and part of Russia but Georgia is not connected to the Russian railway. The only possibility to transport to Russian territory is a link throw Abkhazia. This link is not operational at this time because some conflicts in that region. The roads in Georgia are in a poor condition as well

(World Bank, 2004), therefore at the moment this rute is not able to compete with the N/S Corridor, but it can be a threat for the corridor in the future.

3.5 Conclusion

As the maps show the Caspian Sea Route in the N/S Corridor always reduces the coverage area, because it increases cargo handling costs and delays in ports. Therefore the Equi-Cost curves of X1, X3, X5 and X7 from the maps could be removed and the limits of N/S Corridor could be considered as the X2, X4, X6 and X8.

When the origin of cargo is Bombay toward Hamburg, the North-South Corridor covers more area of land in Russia than when the origin of cargo is Singapore (see maps). The coverage area in all possibilities on the mini land bridge never exceed from the Russian borders with eastern European countries. There are several reasons for lack of efficiency in the North-South Corridor that limits its capability and competency as compared to the North European Route. Efficiency of a route depends on some parameters, and any change in these parameters can expand the coverage area that is calculated in this chapter. In the next chapter the effects of these parameters are investigated in more detail.

For road transport the same calculation generates different curves, but in general the results do not generate any big difference by rail transport.

Chapter 4

Assessment of the changes in parameters on the routes

As explained in Chapter 3, under optimal conditions, the North-South Corridor coverage area is limited to the Eastern European countries border with Russia from the west and some hundreds of kilometres to Moscow from the north. Importing high value cargo from S/E Asia and India to Iran, CIS (Commonwealth of Independent States) countries and southern half of Russia is more economical when this corridor is used. For North, East and Central European countries and the northern part of Russia it is more favourable to use the Suez Canal Route and northern European ports when transporting imports of high value cargo from S/E Asia and India.

The calculation for comparison was based on different parameters. These parameters are not fixed and will change with time, value of cargo or level of risk. Consequently, changes in parameters result in changes in costs and the curves can move in favour of one route rather than another. In the following the effects of these parameters are investigated.

4.1 Capital cost

Two out of four sources of costs that were investigated in Chapters 2 and 3 are directly interrelated to the purchase price of the cargo, namely time and risk costs. Any increase or decrease in the value of the cargo directly increase or decrease time and risk cost of cargo in both routes. For example, if the cargo price increases 10%, the time cost and risk cost increase 10% each, but the total cost will increase less than 10% because other parts of it including outlay cost and THC are not dependent on the purchase price of the cargo. By using Table 18 for these costs as a particular case, the dependency of total cost to time and risk costs on both routes will be:

Table 22: Dependency of total-cost to capital-cost of cargo in Bombay-Helsinki Equi-Cost Curve

	outlay	time cost	risk cost	THC	total	dependancy
N/S Corridor	2095	403	600	750	3847	26%
Suez Canal	2262	1095	240	250	3847	35%

Source: Author

If the capital cost of cargo increases 10%, the total cost of transport in the North-South Corridor will increase 2.6%, whereas on the Suez Canal route it will increase 3.5%. Clearly, increase in the capital cost is in favour of the North-South Corridor and will shift the Equi-Cost Curve of X7 in Map 4 more toward the north, and expand the coverage area of the North-South Corridor. For other origins and destinations the approach is the same.

Increase in discount rates has the same effect, because as same as purchase price of cargo it has direct dependency with time and risk costs.

4.2 Fuel cost

According to Table 3 between 50 to 67% of the total voyage cost and around 22 to 27% of the total cost of a ship is bunkering, it is a high dependency. Whereas land transport dependency on fuel is less because:

1- The percentage of fuel cost in the total cost of land transport is less than the total cost in sea transport. For example, in Europe according to figures in Table 1 for road transport the fuel cost is US$0.16 per each km. For average speed of 36.4 km the total cost of transport per km will be:

Total cost per km per TEU = (21.77/36.4)+0.24 = 0.84

Dependency to fuel = 0.16/0.84 = **19%**

Where: US$21.77=cost per hour

US$0.24=cost per kilometre

US$0.16=fuel cost per kilometre

But this dependency in shipping is more than 22%.

2- Iran and Russia are producers of oil. Iran subsidises fuel cost in the country and the government in Russia controls the price of fuel. Therefore, the international price of fuel has no significant effect on transport costs in these countries.

The same condition is valid for rail transport. Railways are more supported by the governments against changes in fuel price.

Therefore, any increase in fuel cost, that directly increases the outlay cost of ships and terminal handling costs will expand the coverage area of the North-South Corridor more toward the north European ports.

4.3 Balance of trade

Balance of trade between S/E Asia and Europe can affect outlay cost for both sides. At the moment the trade is unbalanced because there are more cargo to be transported from S/E Asia to Europe than from Europe to S/E Asia. The trade between Iran, Russia and CIS countries with S/E Asia is more unbalanced than Northern Europe and S/E Asia, because these countries' exports are mostly raw materials and their industries are not yet fully containerized. Trains have to return without loads and trucks stay idle for a long time to receive enough cargo for the return voyage. By containerization even for low value cargos like timber, steel and petrochemical products, balance in trade for the North-South Corridor can be achieved. If there is sufficient cargo to cover the total costs on the return voyage, the outlay cost will be reduced on both sides.

The presumed balance of trade factor for different modes of transport is:

Table 23: Bc. (Balance factor) for different modes on two routes

Bc.	**Sea**	**rail**	**road**
N/S Corridor	1.2	1.3	1.2
Suez Canal	1.1	1	1.2

Source: Author

The outlay cost on both routes directly depends on these factors, but the total cost in the Suez Canal depends more on Bc. factor than the N/S Corridor:

Table 24: Dependency of total-cost to outlay-cost in Bombay-Helsinki

	outlay	time cost	risk cost	THC	total	dependancy
N/S Corridor	2095	403	600	750	3847	54%
Suez Canal	2262	1095	240	250	3847	59%

Source: Author

According to the high dependency of total cost on outlay cost, more balance in trade can increase the coverage area of the Suez Canal Route toward the Southern half of Russia and CIS countries very little, because, the difference in dependency is not so big. Therefore, the effect can be negligible if the cargo volume in the both routes becomes more balance in the same way.

4.4 Economies of scale

At the moment the amount of cargo is not sufficient in the N/S Corridor. Trains and vehicles could not find enough cargo to use their full capacity. But on the Suez Canal Route because of the traditional situation there is sufficient demand for cargo, and ships are using their full capacity. The factor of economies of scale for different modes of transport, as described in Chapter 2, is:

Table 25: Ec. (economies of scale) factor for different modes on both routes

Ec.	Sea	rail	road
N/S Corridor	1.2	1.2	1
Suez Canal	1	1	1

Source: Author

The dependency of total cost on outlay cost, which is similar to the balance factor, is direct. According to Table 25 any change in lots of cargo on the same way on the both routes will shift the Equi-Cost curve in favour of the Suez Canal. But by developing in the N/S Corridor and by encouraging shippers to use this corridor instead of the Suez Canal, the Ec. Factor can be reduced in favour of the N/S Corridor. Consequently, the curves will shift to eastern European countries.

4.5 Idle times

When the cargo is high value, transit time becomes very important and an effective factor in the total cost. Not only the time value directly depends on transit time but also outlay cost depends on it partially, because employing vehicles for a longer time will increase hour cost by Hour factor. In addition, when the cargo stays idle in ports or distribution centres, other costs like warehousing, safety cost and double handling are avoidable. There are two major causes for longer transit time: low speed in transport means and delay in connection points, such as borders, ports and terminals or ICDs (Inland Custom Depots).

Total costs of both routes are highly dependant on the transit time. The level of dependency is approximately the same because only the risk cost and THC are free from the effects of time, and they are a small fraction of the total cost. Obviously the risk cost can be reduced in case of shorter transit time, but this research assumed that the risk cost as a function of probability of damage or loss, and effect of transit time on risk cost is not measurable. Indeed this effect is also the same for both routes.

The speed of transport at sea can be increase by ship sailing speed and reduction in idle times and turn around time in ports. The transit time can be reduced on land by increase in land transport speed as well as reduction of the idle times in terminals, stations and connecting points such as borders.

One of the main obstacles in using land transport is the delay times on borders for customs clearance, passport checking and other documentation procedures for entering the new territories. Reduction time in ports and border passing times have a same effect on the coverage area of both routes. Increase in sea transport speed will change the Equi-Cost curve in favour of the Suez Canal Route, whereas an increase in land transport speed will change that curve in favour of the N/S Corridor, because the bigger part of the N/S Corridor is passed through the land.

4.6 Level of risk

The risk cost is directly related to the level of safety and security of the route. The dependency of total cost to risk cost for both routes is:

Table 26: Dependency of total-costs to the level of risk in Bombay-Helsinki

	risk cost	total	dependency
N/S Corridor	600	3847	16%
Suez Canal	240	3847	6%

Source: Author

Change in probability of damage or loss will shift the Equi-Cost curves more efficiently in the North-South Corridor, because dependency of total cost on risk cost on that route is more than the Suez Canal Route.

4.7 Conclusion

Results of investigation on the effects of parameters on the transport cost and coverage area of each route, clearly introduce a way of increasing the efficiency of the routes to attract more cargo by providing better service and lower transport price. The most critical parameters are transit time, capital cost and fuel cost, but the risk cost, the balance factor and the economies of scale factor also can change the borders of coverage area on both routes.

In the next chapter recommendations based on results of this chapter will provide the guidelines to increase efficiency and coverage area of each route.

Chapter 5

Conclusions and Recommendations

5.1 Conclusions

Using a new route as a new possibility in transport can reduce costs, save time and provide better flexibility. In the previous chapters the Suez Canal Route as a traditional ocean transport passage was considered to be substitute by the North-South Corridor as a new route for multimodal transport with a considerable capacity and well-established infrastructure. But results showed For the northern European destinations the N/S Corridor is not suitable and the traditional sea transport route via Suez Canal is still a preferable option.
The result of that investigation conducted the research to generate a set of curves to limit the areas that each route can competitively cover. These curves are sketched in Map 1 to 4 (see p. 40-47). According to these maps the central Asian countries and west and southern Russia are located in the coverage area of N/S Corridor and northern Russia and European countries are located in the coverage area of Northern European Route (the Suez Canal Route). This investigation was based on comparison between total costs of transport on each route including freight cost, time cost and risk cost.

Because of some technical and coordinating problems explained in Chapter 4 the N/S Corridor coverage area is not so far from the Russian borders with eastern European countries. And for all Europe and the north part of Russia using the Northern European Route is still a better option. From the other point of view the Black Sea Route may be a threat for the present N/S Corridor coverage area as well in the long term.

The Equi-Cost Curves are also shown that the direct delivery by rail via Djolfa in the N/S Corridor is more productive than using the Caspian Sea.

5.2 Recommendations

At the moment to develop the N/S Corridor, a governmental preliminary secretariat has been established in Iran as the Depositary State (INSTC, 2004). In this regard the following recommendations are made.

5.2.1 Time

Because of the high value of containerized cargo, the time is a sensitive element in the total cost. Reduction in the transit time can reduce total cost as explained in Chapter 4. Two factors can affect the transit time, namely speed and unproductive time.

5.2.1.1 Speed

The speed of ships is around 20 to 22 knots, and the Average speed in the Suez Canal Route including port around time and other waiting times is 14 knots. Ships can hardly increase their speed more than that, but they can reduce their waiting times and turn around times in ports. In land transport the situation is different. The average speed of road and rail transport including waiting times especially in Iran is very low (27.3 km/h for trains (ESCAP, 2001) and 35.5 km/h for trucks). It comes from the maximum speed of 60 km/h for trains and 80 km/h for trucks. Speed can increase by using new technology not only in locomotives and trucks but also on rails and roads. Waiting times in stations and terminals can be reduced more than 50% by more effective control, management and IT supports.

The speed of land transport on the N/S Corridor can increase by factor two; it needs investment in new technology and change in rail and road infrastructures. Land transport speed in the N/S Corridor can rise from 27.3 km/h to more than 55 km/h, but in the best case the ship speed cannot increase more than 1.3 times on the Suez Canal Route. Therefore, the speed of transport is a good opportunity for the

N/S Corridor to increase its coverage area, by investing in the trains and trucks speed and thus reducing the total transit time.

5.2.1.2 Unproductive times

Another factor that affect transit time is the unproductive times when the cargo is in terminals, ICDs, borders and ports. These times are more often in the multimodal transport because the cargo has to be handed over several times by the different means of transport, different rail gauge sizes, and passing the borders between different countries. Each handover needs time and causes expenditure. The assumption of two days idle time in ports for handover cargo to land transport and one day idle time for border passing in this research is not so far from reality. Better cooperation between administrations involved like custom offices, port authorities, port operators and transport companies, and also better facilitation for transport between countries by bilateral and multilateral treaties can reduce these times on the route. Reduction in the transit time on route is equal to increase in the coverage area of the route and increase tonnage.

5.2.2 Cost-benefit analysis

Improvement in infrastructures by investing in roads, rail and superstructures such as high-speed trains will reduce transit time. At the moment the statistics of cargo volume that transport via the corridor are not available, but the needs of a population around 100 million people of central Asia and southern Russia is an opportunity for the corridor in the long-term. To invest on new technology and infrastructure to increase transport speed would attract more cargo in the larger coverage area; a cost-benefit analysis needs to be carried out. The benefits of cargo transit via a country comprises of direct, indirect and induced effects. In the macro-economic scale these effects can be huge when every job creation and value addition in the long-term is considered. Cost-benefit analysis can show the length of time that the investment will be paid back.

The Inter-Governmental Agreement on International North-South Transport Corridor between India, Iran, and Russia was established to facilitate transport cargo via the N/S Corridor in 2000 (ESCAP, 2001). The author believes that If the situation does not change in the North European Route in the next 5 years and cost-benefit analyses show that the cost of investment in the N/S Corridor would be covered by benefits of additional transit cargo in the involved countries, the corridor can attract at least 50% of the cargo that is transported from S/E Asia to Eastern Europe and Central Asia in a mid range plan at around 5 years. Therefore, reduction in transit time must be the highest priority for governments and authorities involved in N/S Corridor.

5.2.3 Threat for N/S Corridor

The border of the European Union (EU) expanded to the east after 15 new States joined in June 2004. Expansion of the EU is eliminated some intermediate borders; therefore, unproductive time on land transport in the North European Route is reduced by two borders (from Hamburg, border of Germany to Poland and Poland to Ukraine if the railway of Ukraine is used instead of that of Belarus). It can increase the coverage area of that route more toward the eastern and southern Russia. The N/S Corridor involved governments need to react quickly by reducing transit time; otherwise the EU can diminish all advantages of the corridor by reducing unproductive times at borders and thus speeding up transport.

Other priority of action for the involved countries in N/S Corridor is explained briefly in the following.

5.2.4 Valuable Cargo

As the advantages of N/S Corridor is in time not in cost, if the capital cost of cargo increases, the coverage area of the N/S Corridor will increase too. The administration and countries involved in transport via the N/S Corridor have to try to attract more valuable cargo rather than low value cargo. To encourage valuable

cargo owners to use this route, reliability and security of cargo during the voyage is crucial.

For valuable cargo air transport can also play an effective role, this is neglected in the N/S Corridor agreement. For a level of purchase price of cargo it is obviously reasonable to use airplanes for part of the transport. Mehr Abad Iranian international airport in Tehran with more than 2000 m above the sea level and less than 4 hours to central Europe can take an essential role in multimodal transport in the corridor. Using other means of transport for higher value cargo is a further research area to investigate.

5.2.5 Law and rules

Change in trading pattern that resulted from globalization is one of the forces to develop a route or a new way of transport; technologies can help this development by providing new ways of transport and reducing the costs. But the change needs to have one link more to boost this development: regulation or in the better sense deregulation (Muller, 1999). Sea transport because of its historical background is well regulated. There are international accepted rules such as the Hague Rules or Hamburg Rules that define the liabilities in sea transport. For road and rail transport there are also specific rules and treaties that have been ratified by a large number of countries but regarding multimodal transport there is still a long way to go. The MT (Multimodal Transport) Convention is introduced in 1980 (UNCTAD, 1995), but only a few countries have ratified it so far. It can regulate and facilitate this kind of transport on the routes.

The MT Convention defines liabilities of shippers and carriers not so different from other sea or land transport conventions; therefore, by the existing conventions or bi or multilateral treaties regulation of transport in the N/S Corridor is quite possible.

Fortunately, Iran and Russia as the main involved countries on that route ratified a good number of trade facilitation instruments like FAL, UN/CFACT, ICC500 (UN/CFACT, 2001). Both countries have also ratified and implemented the Hague Rules. Therefore, there is a considerable capacity to implement supporting rules by administrations in these countries to facilitate multimodal transport.

While a country has accepted a convention, it needs to be incorporated into the national legislation. Legislation in EU for supporting multimodal transport is well organized, therefore the Suez Canal Route is relatively in a good situation at the moment, but for the N/S Corridor, national legislations need to be revised. The countries involved in the N/S Corridor need to ratify a specific code to facilitate this kind of transport and make uniformity in the rules and clarify the liabilities of the players in all countries involved. Further investigation related to this research could be to find the grids and basic framework of this code.

5.2.6 IT and information

Now the Information Technology helps every industry, not only to control the product line and distribution networks but also to have accurate information from customers.
Using the IT to organize the transport by a dedicated responsible administration on the route cannot only reduce the outlay cost by avoiding or reducing unexpected costs, but can also reduce the time cost by reducing idle times, as well as reducing risk costs by tracking the cargo for example. The N/S Corridor involved countries by establishing an administration responsible for organizing effective network to control transport without reduction in competition will be able to improve efficiency of transport on this route and increase the coverage area.
Customer relationship management can be handled by installing a software network to maintain contacts with the shippers and provide fast responds to change in case of any change in the needs or taste of users.

Providing reliable information for shippers and users of the route is another duty of the above-mentioned administration. At the moment risk of damage or loss of cargo in the N/S Corridor is higher than in the Suez Canal because some unfulfilled carriers work in this route. The administration must allow only authorized companies to work as freight forwarders or Multimodal Transport Organizations (MTOs) on that route and inform shippers about these players. Obviously, authorization shall not reduce the competition.

5.2.7 Customer awareness

Shippers as users of a route need to know all the details of any situation of the route. No one ships a parcel on a dark route. Providing all detailed information about a route is essential for the customer, because cargo owners do not like risk of extra costs or unpredictable delay or loss and damage to cargo. Any ambiguity on a route can set it aside by the users. Administrations involved in developing the N/S Corridor must pay attention to shippers' requests of information. Internet is a good opportunity to publish reliable and updated information; therefore, investment in establishing a well structure web-side and fast responding to customer information demands is a fundamental need. Recruiting well-educated and responsible people for customer relationship and using motivation tools, advertisement and providing a user-friendly network to respond to any customer needs in a short time is a basic requirement of the corridor. Providing a centre for following customer claims and keeping the users satisfaction a promised level can improve the efficiency of the route and increase the volume of cargo transported via this corridor.

5.2.8 Value added activities

Finally one of the most important advantages of multimodality in transport is flexibility. On the Suez Canal Route, the port of Hamburg not only hands over cargo from sea transport to land transport means, but also works as a distribution centre, warehouse, consolidation centre and even as a part of the production line of manufactured cargo adding some value on it. For administrations responsible for developing the N/S Corridor, using this flexibility to provide better customer satisfaction is vital. On the land bridge there are wide ranges of choices to transport, storage or value added activities. By providing tailor made services for users, not only the countries and players on the route can gain money and generate more jobs, but also customers will have better satisfaction. It can provide a win-win situation for the users and the countries in the corridor. Investigating the capacity of the countries involved in the route to become part of the value chain in the users production line is another area for research.

References

Bartholomew Ltd. & Time Books (1999). *The Times comprehensive atlas of the world.* London: Time Books

Blauwens, G., De Beere, P. & Voorde, E. (2002). *Transport economics*. Antwerpen: Uitgeverij De Boeck nv.

Button, K.J. & Pitfield, D.E. (1985). *International railway economies.* London: Gower Publishing.

Canadian Trade Commissioner Service. (2001, October). Insuring your shipment. *International Shipping and Distribution.* Retrieved July 9 2004 from: http://www.infoexport.gc.ca/shipping/insureship-e.htm

Drewry Shipping Consultants. (1997). *Ship costs: The economics of acquisition and operation.* London: Author.

Drewry Shipping Consultants. (2002). *Ship operation costs: Annual review & forecast 2004/05.* London: Author.

European Commission. (2001). *The economic impact of carrier liability on intermodal freight transport: Executive summary.* Luxembourg: Office for Official Publications of the European Communities.

Iran, Ministry of Road and Transport (2001), *Freight rates of rail transport, 2001,* Tehran: Author. [Title translated from Persian].

Iran, Ministry of Road and Transport, International North–South Transport Corridor [INSTC]. (2004). *International North–South Transport Corridor.* Retrieved July 27 2004 from: http://www.instc.org/aboutus/aboutus.asp

Lloyd's Register-Fairplay. (2002). Distance tables 2002. *World shipping encyclopaedia* [CD-Rom]. London: Author

Luo, M. & Grigalunas, T.A. (2002). *A spatial-economic multimodal transportation simulation model for US coastal container ports.* Paper presented at the IAME Panama 2002 Conference,13-15 November 2002, Panama City, Panama.

Ma S. (2003). *Maritime economics.* Unpublished lecture handout, World Maritime University, Malmo, Sweden.

Muller, G. (1999). *Intermodal freight transportation* (4th ed.). Washington, D.C.: Eno Transport Foundation, Inc.

Ott, A. (2004). Comparable cost calculation for infrastructure of road and rail. *Workshop on Applied Infrastructure Research, October 12, 2002, Berlin*. Berlin: Berlin University of Technology. Workgroup for Infrastructure Policy (WIP). Retrieved May 26 2004 from: http://wip.tu-berlin.de/workshop/2002/papers/tu-berlin_wip_workshop_2002-paper_Ott-infrastructure_costs_road_rail.pdf

Ratcliffe B., (1987). *Economy and efficiency in transport and distribution* (2nd ed.). London: Kogan Page.

Singapore Port Authority (2004). *Port statistics: Total container throughput.* Retrieved July 27 2004 from: http://www.mpa.gov.sg/homepage/portstats/container-throughput.pdf

Stopford, M. (1997). *Maritime economics* (2nd edition). London; New York: Routledge.

Suez Canal Authority. (2002). *Suez Canal yearly report.* Ismailia, Egypt: Author.

Tarski, I. (1987). *The time factor in transportation processes.* Amsterdam; New York: Elsevier

United Nations, Centre for Trade Facilitation and Electronic Business [UN/CEFACT] (2001). *Compendium of trade facilitation recommendations.* New York: United Nations.

United Nations Conference on Trade and Development [UNCTAD]. (1995). *Multimodal transport handbook* (UNCTAD/SHIP/Misc.68/ Rev.1). Geneva: Author

UNCTAD. (2002*). Review of maritime transport*. New York; Geneva: United Nations.

United Nations, Economic and Social Commission for Asia and the Pacific [ESCAP], (2001). *Development of the trans-Asian railway; Trans-Asian railway in the North-South Corridor, northern Europe to the Persian Gulf* (ST/ESCAP/2182). Geneva: United Nations.

World Bank (2004). *Georgia country brief, 2003.* Retrieved July 9 2004 from: http://wbln0018.worldbank.org/ECA/Transport.nsf/Countries/Georgia?Opendocument

Appendix 1: Cost calculation for different routes and possibilities

Appendix 1: cost calculation between different routes and possibilities

sea transport **All amount in US$**

	capital cost	operation costs					voyage cost			cost per teu				
ship size	**capital**	**manning**	**insurance**	**R & M**	**supplies**	**overhead**	**bunker**	**dues & charges**		**total**	**per day**	**Bc.**	**Ec.**	**total**
4000	17000	1842	740	2330	1781	4739	17000	9810	7000	62242	16	1.1	1	17
2000	11000	1600	614	1836	1671	3344	8670	0	5000	33735	17	1.2	1.2	24
300	2466	1400	422	411	548	1049	2040	0	1000	9336	31	1.3	1.2	49

Road Transport

Bc. = Balance Factor

Ec. = Economic of scale F **CHC+B** 540

	H	**K**	**Bc.**	**Ec.**
Iran	9.93	0.11	1.2	1
Russia	9.03	0.17	1.2	1
Europe	21.77	0.24	1.2	1

H = Hour Coefficiant

K = Kilometre Coefficiant

H calcu.	Interest	Insura	tax	wage	Others	**H**
Iran	3.13	0.5	0.3	5	1	9.93
Russia	3.13	0.6	0.3	4	1	9.03
Europe	3.13	1.75	0.63	14.38	1.88	21.77
K calcu.	Interest	Fuel	Tires	Maintenance		**K**
Iran	0.04	0.04	0.01	0.02		0.11
Russia	0.04	0.1	0.01	0.02		0.17
Europe	0.04	0.16	0.01	0.03		0.24

Rail Transport

	Avo. cost	**Bc.**	**Ec.**
Iran	0.2	1.3	1.2
Russia	0.2	1.3	1.2
Europe	0.5	1	1

N/S Corridor (sea, rail)	Km	Days	US$	**Time cost**	**Damage pro.**	**Risk cost**	**THC**	**TOTAL**
	Distance	time	total outlay		0.50%	600		600
Bombay to Bandar Abbas	1687	3.5	625	109			250	984
Bandar Abbas to Amir Abad	1743	4.7	544	147			250	941
Amir Abad to Astarakhan	1400	4	734	125			250	1109
Astrakhan to hamburg	3726	7.3	1163	227				1389
Sum	8556	19	3066	608		600	750	5023

Suez Route(sea, rail)	Km	Days	US$	**Time cost**	**Damage pro.**	**Risk cost**	**THC**	**TOTAL**
	Distance	time	total outlay		0.20%	240		240
Bombay to hamburg	10482	20.5	891	641			250	1782
Hamburg to X	0	0.0	0	0				0
Sum	10482	21	891	641		240	250	2022

Cargo Porchase price	120000

inter. rate	0.026%

Speed: 36.4

N/S Corridor (sea, road)	Km	Days	US$	Time cost	Damage pro.	Risk cost	THC	TOTAL
	Distance	time	total outlay		0.60%	720		720
Bombay to Bandar Abbas	1687	3.5	625	109			250	984
Bandar Abbas to Amir Abad	1743	4	611	125			250	986
Amir Abad to Astarakhan	1400	4	734	125			250	1109
Astrakhan to Hamburg	3726	7.3	1393	228				1621
Sum	8556	18.8	3364	587		720	750	5420

Suez Route(sea, road)	Km	Days	US$	Time cost	Damage pro.	Risk cost	THC	TOTAL
	Distance	time	total outlay		0.20%	240		240
Bombay to hamburg	10482	20.5	891	641				1532
Hamburg to Hamburg	0	0	0	0				0
Sum	10482	20.5	891	641		240	0	1772

Bombay to Hamburg

N/S Corridor (sea, rail)	Km	Days	US$	Time cost	Damage pro.	Risk cost	THC	TOTAL
	Distance	time	total outlay		0.40%	480		480
Bombay to Bandar Abbas	1687	3.5	625	109			250	984
Bandar Abbas to Djolfa	2325	5.5	725	172			250	1147
Djolfa to Hamburg	4776	10.5	1490	327				1817
Sum	8788	19	2841	608		480	500	4428

Bombay to Hamburg	Money out	distance	Days	Total cost
Via Caspian Sea	3066	8556	19.5	5023
Via Djolfa	2841	8788	19.5	4428
Via Suez Canal	891	10482	20.5	1772

sea transport **All amount in US$**

	capital cost	operation costs					voyage cost			cost per teu				
ship size	**capital**	**manning**	**insurance**	**R & M**	**supplies**	**overhead**	**bunke**	**dues & charges**		**total**	**per day**	**Bc.**	**Ec.**	**total**
4000	17000	1842	740	2330	1781	4739	17000	9810	7000	62242	16	1.1	1	17
2000	11000	1600	614	1836	1671	3344	8670	0	5000	33735	17	1.2	1.2	24
300	2466	1400	422	411	548	1049	2040	0	1000	9336	31	1.3	1.2	49

Road Transport

	H	K	Bc.	Ec.
Iran	9.93	0.11	1.2	1
Russia	9.03	0.17	1.2	1
Europe	21.77	0.24	1	1

Bc. = Balance Factor

Ec. = Economic of scale F CHC+B 540

H = Hour Coefficiant

K = Kilometre Coefficiant

H calcu.	Interest	Insura	tax	wage	Others	**H**
Iran	3.13	0.5	0.3	5	1	9.93
Russia	3.13	0.6	0.3	4	1	9.03
Europe	3.13	1.75	0.63	14.38	1.88	21.77
K calcu.	Interest	Fuel	Tires	Maintenance		**K**
Iran	0.04	0.04	0.01	0.02		0.11
Russia	0.04	0.1	0.01	0.02		0.17
Europe	0.04	0.16	0.01	0.03		0.24

Rail Transport

	Avo. cost	Bc.	Ec.
Iran	0.2	1.3	1.2
Russia	0.2	1.3	1.2
Europe	0.5	1	1

N/S Corridor (sea, rail)	Km	Days	US$	**Time cost**	**Damage pro.**	**Risk cost**	**THC**	**TOTAL**
	Distance	time	total outlay		0.50%	600		600
Singapore to Bandar Abbas	5368	10.5	795	328			250	1373
Bandar Abbas to Amir Abad	1743	4.7	544	147			250	941
Amir Abad to Astarakhan	1400	4	734	125			250	1109
Astrakhan to Hamburg	3726	7.3	1163	228				1390
Sum	12237	26.5	3236	828		600	750	5413

Suez Route (total sea)	Km	Days	US$	**Time cost**	**Damage pro.**	**Risk cost**	**THC**	**TOTAL**
	Distance	time	total outlay		0.20%	240		240
Singapoure to Hamburg	13607	27	1002	845				1847
Sum	13607	27	1002	845		240	0	2087

Cargo Porchase price	120000

inter. rate	0.026%

N/S Corridor (sea, road)	Km	Days	US$	Time cost	Damage pro.	Risk cost	THC	TOTAL
	Distance	time	total outlay		0.60%	720		720
Singapore to Bandar Abbas	5368	10.5	795	328			250	1373
Bandar Abbas to Amir Abad	1743	4	611	125			250	986
Amir Abad to Astarakhan	1400	4	734	125			250	1109
Astrakhan to Hamburg	3726	6.3	1306	197				1503
Sum	12237	24.8	3447	774		720	750	5691

Suez Route (sea, road)	Km	Days	US$	Time cost	Damage pro.	Risk cost	THC	TOTAL
	Distance	time	total outlay		0.20%	240		240
Singapoure to Hamburg	13600	27	1002	845				1847
Hamburg to Hamburg	0	0	0	0				0
Sum	13600	27	1002	845		240	0	2087

Singapore to Hamburg

N/S Corridor (sea, rail)	Km	Days	US$	Time cost	Damage pro.	Risk cost	THC	TOTAL
	Distance	time	total outlay		0.40%	480		480
Singapore to Bandar Abbas	5368	10.5	795	328			250	1373
Bandar Abbas to Djolfa	2325	5.5	725	172			250	1147
Djolfa to Hamburg	4776	10.5	1490	328				1818
Sum	12469	26.5	3011	828		480	500	4818

Singapore to Hamburg	Money out	distance	Days	Total cost
Via Caspian Sea	3236	12237	26.5	5413
Via Djolfa	3011	12469	26.5	4818
Via Suez Canal	1002	13600	27	2087

sea transport **All amount in US$**

	capital cost	operation costs					voyage cost			cost per teu				
ship size	**capital**	**manning**	**insurance**	**R & M**	**supplies**	**overhead**	**bunker**	**dues & charges**		**total**	**per day**	**Bc.**	**Ec.**	**total**
4000	17000	1842	740	2330	1781	4739	17000	9810	7000	62242	16	1.1	1	17
2000	11000	1600	614	1836	1671	3344	8670	0	5000	33735	17	1.2	1.2	24
300	2466	1400	422	411	548	1049	2040	0	1000	9336	31	1.3	1.2	49

Road Transport

	H	K	Bc.	Ec.
Iran	9.93	0.11	1.2	1
Russia	9.03	0.17	1.2	1
Europe	21.77	0.24	1.2	1

Bc. = Balance Factor

Ec. = Economic of scale F **CHC+B** 540

H = Hour Coefficiant

K = Kilometre Coefficiant

H calcu.	Interest	Insurar	tax	wage	Others	**H**
Iran	3.13	0.5	0.3	5	1	9.93
Russia	3.13	0.6	0.3	4	1	9.03
Europe	3.13	1.75	0.63	14.38	1.88	21.77
K calcu.	Interest	Fuel	Tires	Maintenance		**K**
Iran	0.04	0.04	0.01	0.02		0.11
Russia	0.04	0.1	0.01	0.02		0.17
Europe	0.04	0.16	0.01	0.03		0.24

Rail Transport

	Avo. cost	Bc.	Ec.
Iran	0.2	1.3	1.2
Russia	0.2	1.3	1.2
Europe	0.5	1	1

N/S Corridor (sea, rail)	Km	Days	US$	**Time cost**	**Damage pro.**	**Risk cost**	**THC**	**TOTAL**
	Distance	time	total outlay		0.50%	600		600
Bombay to Bandar Abbas	1687	3.5	625	109			250	984
Bandar Abbas to Amir Abad	1743	4.7	544	147			250	941
Amir Abad to Astarakhan	1400	4	734	125			250	1109
Astrakhan to Helsinki	3059	3.5	954	109				1064
Sum	7889	15.7	2857	490		600	750	4697

Suez Route(sea, rail)	Km	Days	US$	**Time cost**	**Damage pro.**	**Risk cost**	**THC**	**TOTAL**
	Distance	time	total outlay		0.20%	240		240
Bombay to Helsinki	14964	29.2	1040	914				1954
Hamburg to Hamburg	0	0	0	0				0
Sum	14964	29	1040	914		240	0	2194

Cargo Porchase price	120000

inter. rate	0.026%

N/S Corridor (sea, road)	Km	Days	US$	Time cost	Damage pro.	Risk cost	THC	TOTAL
	Distance	time	total outlay		0.60%	720		720
Bombay to Bandar Abbas	1687	3.5	625	109			250	984
Bandar Abbas to Amir Abad	1743	4	611	125			250	986
Amir Abad to Astarakhan	1400	4	734	125			250	1109
Astrakhan to Helsinki	3059	3.5	927	109				1037
Sum	7889	15	2898	468		720	750	4836

Suez Route (sea, road)	Km	Days	US$	Time cost	Damage pro.	Risk cost	THC	TOTAL
	Distance	time	total outlay		0.20%	240		240
Bombay to Helsinki	14964	29.2	1040	914				1954
Hamburg to Hamburg	0	0	0	0				0
Sum	14964	29.2	1040	914		240	0	2194

Bombay to Helsinki

N/S Corridor (sea, rail)	Km	Days	US$	Time cost	Damage pro.	Risk cost	THC	TOTAL
	Distance	time	total outlay		0.40%	480		480
Bombay to Bandar Abbas	1687	3.5	625	109			250	984
Bandar Abbas to Djolfa	2325	5.5	725	172			250	1147
Djolfa to Helsinki	4176	6.8	1303	212				1515
Sum	8188	15.8	2653	493		480	500	4127

Bombay to Helsinki	Money out	distance	Days	Total cost
Via Caspian Sea	2857	7889	15.7	4697
Via Djolfa	2653	8188	15.8	4127
Via Suez Canal	1040	14964	29.2	2194

sea transport **All amount in US$**

	capital cost	operation costs					voyage cost			cost per teu				
ship size	**capital**	**manning**	**insurance**	**R & M**	**supplies**	**overhead**	**bunke**	**dues & charges**		**total**	**per day**	**Bc.**	**Ec.**	**total**
4000	17000	1842	740	2330	1781	4739	17000	9810	7000	62242	16	1.1	1	17
2000	11000	1600	614	1836	1671	3344	8670	0	5000	33735	17	1.2	1.2	24
300	2466	1400	422	411	548	1049	2040	0	1000	9336	31	1.3	1.2	49

Road Transport

	H	K	Bc.	Ec.
Iran	9.93	0.11	1.2	1
Russia	9.03	0.17	1.2	1
Europe	21.77	0.24	1	1

H = Hour Coefficiant

K = Kilometre Coefficiant

Bc. = Balance Factor

Ec. = Economic of scale F **CHC+BAF** 540

H calcu.	Interest	Insura	tax	wage	Others	**H**
Iran	3.13	0.5	0.3	5	1	9.93
Russia	3.13	0.6	0.3	4	1	9.03
Europe	3.13	1.75	0.63	14.38	1.88	21.77
K calcu.	Interest	Fuel	Tires	Maintenance		**K**
Iran	0.04	0.04	0.01	0.02		0.11
Russia	0.04	0.1	0.01	0.02		0.17
Europe	0.04	0.16	0.01	0.03		0.24

Rail Transport

	Avo. cost	Bc.	Ec.
Iran	0.2	1.3	1.2
Russia	0.2	1.3	1.2
Europe	0.5	1	1

N/S Corridor (sea, rail)	Km	Days	US$	**Time cost**	**Damage pro.**	**Risk cost**	**THC**	**TOTAL**
	Distance	time	total outlay		0.50%	600		600
Singapore to Bandar Abbas	5368	10.5	795	328			250	1373
Bandar Abbas to Amir Abad	1743	4.7	544	147			250	941
Amir Abad to Astarakhan	1400	4	734	125			250	1109
Astrakhan to Helsinki	3059	3.5	954	109				1064
Sum	11570	22.7	3027	709		600	750	5086

Suez Route (sea, rail)	Km	Days	US$	**Time cost**	**Damage pro.**	**Risk cost**	**THC**	**TOTAL**
	Distance	time	total outlay		0.20%	240		240
Singapoure to Helsinki	14964	29.5	1045	924				1969
Hamburg to Hamburg	0	0	0	0				0
Sum	14964	30	1045	924		240	0	2209

Cargo Porchase price	120000

inter. rate	0.026%

N/S Corridor (sea, road)	Km	Days	US$	Time cost	Damage pro.	Risk cost	THC	TOTAL
	Distance	time	total outlay		0.60%	720		720
Singapore to Bandar Abbas	5368	10.5	795	328			250	1373
Bandar Abbas to Amir Abad	1743	4	611	125			250	986
Amir Abad to Astarakhan	1400	4	734	125			250	1109
Astrakhan to Helsinki	3059	2.7	858	84				942
Sum	11570	21.2	2999	662		720	750	5131

Suez Route (sea, road)	Km	Days	US$	Time cost	Damage pro.	Risk cost	THC	TOTAL
	Distance	time	total outlay		0.20%	240		240
Singapoure to Helsinki	14964	29.5	1045	924				1969
Hamburg to Hamburg	0	0	0	0				0
Sum	14964	29.5	1045	924		240	0	2209

Singapore to Helsinki

N/S Corridor (sea, rail)	Km	Days	US$	Time cost	Damage pro.	Risk cost	THC	TOTAL
	Distance	time	total outlay		0.40%	480		480
Singapore to Bandar Abbas	5368	10.5	795	328			250	1373
Bandar Abbas to Djolfa	2325	5.5	725	172			250	1147
Djolfa to Helsinki	4176	6.8	1303	212				1515
Sum	11869	22.8	2823	712		480	500	4515

Singapore to Helsinki	Money out	distance	Days	Total cost
Via Caspian Sea	3027	11570	22.7	5086
Via Djolfa	2823	11869	22.8	4515
Via Suez Canal	1045	14964	29.5	2209