Improving Decision Making: Route Optimization Techniques for Aqaba Sea Port in Jordan

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Abstract

This study uses linear programming to build transportation and transshipment models in order to test whether the existing actual costs to transport the major Jordanian exports and imports are optimal. The main findings of this research showed evidence about the ineffectiveness of the current policies of transportation and transshipment which stipulates a change towards optimal values to target minimal overall costs of transportation and transshipment. It is recommended that Jordan develops its own shipping fleet to cut drastically the cost of importation through means of economics of scale and bulk shipping.

Keywords: linear programming, transportation, transshipment, optimization, exports, imports, shipping route, minimum cost, total cost, Aqaba sea port, Jordan

1. Introduction

As world economic conditions decline, not only are organization seeking to revise their operational strategies but also countries are taking a second look at how they can be more effective and efficient: Reducing costs, increasing revenues to maximize profit.

Under developed and developing countries have the challenge of reevaluating their current status as they posses limited country resources. A major form of revenue for these countries include the export and import industry. This study will focus on one particular developing country with limited resources in the Middle East (i.e. Jordan), Moreover, this study applies linear programming (LP) as a form of analyses to investigate the current logistical transportation network to identify the best optimal transportation route. Thus, potentially shedding expenses and reducing cost. Jing (2009) indicates that about 90% of world trade is carried by the international shipping service. Therefore, the performance of the shipping industry has a huge impact on world economy, and thus attracts extensive research on it.

Monopolizing the country's main source of trade, shipping is mainly used as a form of large quantity transportation of goods to different continents. To meet the demand, shipping organizations invest high capital in new ships. Shipping vessels are tangible resource to the organization. Resources are needed to increase capabilities. An organizational capability is a "firm's capacity to deploy resources for desired end result" (Grant, 2010). Utilizing fleets in the best possible way to gain competitive advantage.

With greater amounts of vessels increasing in the industry so has become the complexity of scheduling. The intangible resources of optimizing and improving shipping methods are a great concerns and value to organizations.

2. Study Problem

Port of Aqaba is the only seaport in Jordan. As an economic factor, the port handles 65% of the countries imports with an estimated 78% exports (Study Report, 2010). Geographically the port sits as a prime location that connects Jordan to adjacent contents of Asia, Africa and Europe.

Whilst the Jordanian exports are few, quality and cost benefit specific products; imports are numerous which reflect the nature and qualification of the existing of productive system. Also, it matches the modest size of resources as explained in the levels of income, consumption and investment. However, in spite of its limited capacity, the economy succeeded in achieving certain growth rates, but still bellow the required because of the structural imbalances, which brought different sectorial contributions to gross domestic product (Jordan's Competitiveness Report (2007).

There are five major exporting products (i.e.: Phosphate, Fertilizers, Potash, Cement, and General Cargo), and twenty four major importing products (i.e.: Flour, Rice, Sugar, Grains, Vegetable Oil, Cars, Steel and Iron, Timber, Mineral Oil, Construction Materials, Ammonia, Frozen Goods, Government supplies, Tires, Sulfur, Fertilizers, Gas, Fodder, Live Animals, Vegetables & Fruits, Sesame & Beans, Tea/ Coffee, Other Goods and General Goods). These exporting and importing products are shipped through Aqaba Sea port to eleven major blocks of countries, (or to eleven different geographical regions). Applying linear programming and transportation algorithms, the aim of this paper is to find the most efficient sea transportation routes between port of Aqaba and global destinations. In other words, the techniques employed here are to find the least cost model of transportation or transshipment.

3. Importance of the Study

The lack of empirical studies on the area of transportation problems concerning Jordan has been the major reason to conduct this study. This research is the first attempt to use linear programming techniques to assess the efficiency of shipping companies in developing countries in general and Jordan in particular. More precisely, the aim of this study is to identify the relatively efficient shipping routes, the relatively inefficient shipping routes. It is expected that the results of this study would be valuable to policy makers, Aqaba private zone managers, academics, researchers and the public and private sector in general.

4. Related Work

The transportation problem was originally acknowledged by Hitchcock (1941) using linear programming model. Subsequently, several studies, methods, models and implementations have emerged in the literature that developed mathematical algorithms for the transportation problems. Examples include those reported by (Pooler J. and Hu P. 2002; Bertazzi l. et al. 2000; Bostel N. and Dejax P. 1998; Samuelsson A. and Tilanus B. 1997; Bazzaraa M. and Bouzaher A. 1981; Finke G. and Ahrens J.H 1978; Charnes A. and Copper W. 1957; Hsu and Hsieh 2007; Rana, and Vickson 1988; Vis et al. 2005; Christiansen et al. 2004).

To understand the concept of transportation (Anderson et. al. 2012 p. 256) state that "the transportation problem arises frequently in planning for the distribution of goods and services from several supply locations to several demand locations". JI and Chu (2002) state that "The transportation model is a special case of linear programming models". They indicate that "The purpose of transportation modeling is to the least cost means of shipping supplies from several origins to several destinations". Schwartz (1968) developed a discrete programming model for moving accepted cargos from origins to destinations within an allotted time at minimum barge line fleet cost. The development of the model is based on the assumption that the cargo movements to be made and the time needed for transit, loading and unloading are known exactly. In a Canadian dairy firm (Pooley 1994) employed linear programming to minimize transportation cost for supply and distribution. The purpose of using a linear programming was to find the optimal location for new plants. Faulin (2003) optimized transportation costs subject to a set of supply and demand constraints. He developed a model for decision making concerning routing scheduling based on a multi-phase algorithm with a heuristic and an exact facet. Moreover, Go´mez & Salazar (1991) as cited by Faulin (2003) develop a linear programming model that minimizes total transportation cost for the sugar market in Spain and calculate the optimum flows of raw material (sugar-beet) between productive zones and transformation centers.

In this study, the author formulates a linear programming model to assist the decision makers decide the most efficient sea transportation routes between port of Aqaba and global destinations. The author believes that this model addresses the requirements of a developing economy.

5. Formulating the Canonical Form (The Equation Form)

5.1 For Exporting Commodities from Jordan

To formulate the exporting models from Aqaba, the author defines the following equations of eleven decision variables:

Let be χ_{ij} the quantity in tons of the commodity i shipped to destination j

$1 \leq i \leq 5$ five type of commodities (i.e., Phosphate, Fertilizers, Potash, Cement, and General Cargo).

$1 \leq i \leq 11$ eleven destinations (i.e., Far East, South West Asia, Australia and New-Zealand, Gulf countries, East Africa, North and West Africa, West Europe, East Europe, East Mediterranean, the United States and Canada, and the rest of American countries).

The objective function is to minimize the total costs of transportation across the different commodities within the destinations, more technically we can formulate:

$$Min\,TCE = \sum_{i=1}^{24}\sum_{j=1}^{11} c_{ij}x_{ij}$$

Where c_{ij} is the unit cost (thousands of JD) of the commodity i shipped to destination j

Let be also $\bar{x}_{ij}$ the average quantity transported across the years 1998-2007 for the commodity i shipped to destination j

Automatically the five constraints should be defined as follows

$$\begin{cases} \sum_{j=1}^{11} x_{ij} \le \bar{x}_{ij} \\ 1 \le i \le 5 \end{cases}$$

Adding the non-negativity constraint we have to optimize the following linear transportation export model:

$$Min\,TCE = \sum_{i=1}^{5}\sum_{j=1}^{11} c_{ij}x_{ij}$$

S.T:

$$\begin{cases} \sum_{j=1}^{11} x_{ij} \le \bar{x}_{ij} \\ 1 \le i \le 5 \\ x_{ij} \ge 0 \end{cases}$$

5.2 For Importing Commodities to Jordan

Let be x_{ij} the quantity in tons of the commodity i shipped from destination j to Aqaba port (Jordan)

$1\le i \le 24$Twenty Four type of commodities (i.e. Flour, Rice, Sugar, Grains, Vegetable Oil, Cars, Steel and Iron, Timber, Mineral Oil, Construction Materials, Ammonia, Frozen Goods, Government supplies, Tires, Sulfur, Fertilizers, Gas, Fodder, Live Animals, Vegetables & Fruits, Sesame & Beans, Tea/ Coffee, Other Goods and General Goods).

$1\le j \le 11$ eleven destinations (i.e. Far East, South West Asia, Australia and New-Zealand, Gulf countries, East Africa, North and West Africa, West Europe, East Europe, East Mediterranean, the United States and Canada, and the rest of American countries).

i= The individual product being shipped from each region to the final destination; the port of Aqaba; namely *i=1,2,3…….24* and meaning: Flour, Rice, Sugar, Grains, Vegetable Oil, Cars, Steel and Iron, Timber, Mineral Oil, Construction Materials, Ammonia, Frozen Goods, Government supplies, Tires, Sulfur, Fertilizers, Gas, Fodder, Live Animals, Vegetables & Fruits, Sesame & Beans, Tea/ Coffee, Other Goods and General Goods.

The objective function is to minimize the total costs of transportation across the different commodities within the paths, more technically we can formulate

$$Min\,TCE = \sum_{i=1}^{24}\sum_{j=1}^{11} c_{ij}x_{ij}$$

Where c_{ij} is the unit cost (thousands of JD) of transporting one ton of the imported products from the region (*j*); to Aqaba *j=1,2……11*; namely: the Far East, South West Asia, Australia and New-Zealand, Gulf Countries, East Africa, North and West Africa, West Europe, East Europe, East Mediterranean, United States of America Canada, and the Rest of American Countries.

Also, Jordan, here, faces two types of constraints: First, the total tonnage of every importing commodity supplied by the world's regions to Aqaba cannot exceed the total commodities shipped. In other words, the average of the 24 commodities supplied across the years (1998-2008) by the Far East (for example) to Aqaba cannot exceed (76977) tones. Each variable with the number (1) in the first subscript represents a shipment from the Far East.

Consequently, subscripts numbered 1, 2,3, … ….11 represent shipment from South West Asia…. until the last region (i.e. The Rest of American Countries). Hence, we may express this supply

Let be S_j the supply limit coming from the place j

$$\begin{cases} \sum_{i=1}^{24} x_{ij} \leq S_j \\ 1 \leq j \leq 11 \end{cases}$$

Second, we need another constraint to ensure that Aqaba (or Jordan) will receive the required tonnage of each of the Twenty four commodities. Jordan, represented by each commodity arrived at Aqaba is a demand point. For example, from the first commodity (Flour), Aqaba must receive no less than the total tonnage average of (9942.636364) across the years (1998-2008). Hence every second subscript (j) with (1) represents a shipment of flour from the eleven regions (i) in the world to Aqaba. Hence we get the following demand constraints:

Let be D_i the demand limit for the commodity i

$$\begin{cases} \sum_{j=1}^{11} x_{ij} \geq D_i \\ 1 \leq i \leq 24 \end{cases}$$

Adding the non-negativity constraint we have to optimize the following linear transportation imports model:

$$Min\ TCE = \sum_{i=1}^{5} \sum_{j=1}^{11} c_{ij} x_{ij}$$

S.T:

$$\begin{cases} \sum_{i=1}^{24} x_{ij} \leq S_j \\ 1 \leq j \leq 11 \\ \sum_{j=1}^{11} x_{ij} \geq D_i \\ 1 \leq i \leq 24 \\ x_{ij} \geq 0 \end{cases}$$

5.3 Transshipment Models

A transportation problem allows only shipments that go directly from a supply point to a demand point. In many situations, shipments are allowed between supply points or between demand points. Sometimes there may also be points (called transshipment points), through which goods can be transshipped on their journey from a supply point to a demand point. Shipping problems with these characteristics are transshipment problems. The optimal solution to a transshipment problem can be found by solving a transportation problem as follows:

A supply point is defined as that which can send goods to another point, and a demand point is that which can receive goods from other points only. But a transshipment point is that which can both receive goods from other points and send goods to others (Anderson et. al., 2003).

In order to minimize total cost of shipping to Jordan, the author chose some middle points to supply imports or exports from and to the port of Aqaba.

5.3.1 Exports of Jordan as Transshipment

Instead of shipping exports of the five major products from Aqaba port to its final regional destinations, Bombay in India is chosen as a demand point to receive Jordanian exports and send them to the Far East, South West Asia and Australia and New - Zealand, Yanbua as a second demand point which, inter alia, can send goods from Jordan to the Far East, South West Asia, Australia and New - Zealand, Saudi Arabia and Yemen and East Africa, Egypt as a third demand point to receive export goods from Jordan and send them to East Africa, North Africa, East Mediterranean, West Europe and East Europe; Europe as a fourth demand point to receive export goods from Jordan and send them to West Europe, East Europe, the United States and Canada, and the Rest of

American countries, and America as a fifth demand point to receive export goods from Jordan and send them to the United States of America and the Rest of American countries.

Accordingly, as a transshipment problem exports from Jordan will appear as a linear programming case in the following system:

Let be *xijk* the quantity in tons of the commodity i shipped from Aqaba through the demand point j to destination k

$1 \leq i \leq 5$ (five type of commodities)

$1 \leq j \leq 5$ (i.e., midpoint destinations)

$1 \leq k \leq 11$ (final destinations)

The objective function is to minimize the total costs of transshipment across the different commodities within the paths, more technically we can formulate:

$$Min\ TCE = \sum_{j=1}^{5}\sum_{i=1}^{5} c_{ij}x_{ijk} + \sum_{i=1}^{5} c_{ijk}x_{ijk} + \sum_{j=1}^{5} c_{ijk}x_{ijk} + \sum_{k=1}^{11} c_{ijk}x_{ijk}$$

c_{ij} is the cost of transportation of commodity i to mid point j

c_{ijk} is the cost of shipping the commodity i from midpoint j to final destination k

The constraint for the demand at midpoints is:

$$\sum_{i=1}^{5} x_{ijk} = MD_j\ for\ 1 \leq j \leq 5$$

Where MD_j is the demand at the midpoint j

The constraints for the demand at the final destinations are:

$$\sum_{j=1}^{5} x_{ijk} = FD_k\ for\ 1 \leq k \leq 11$$

Where FD_k is the demand at the final destination k

The transshipment constraints are:

$$\sum_{i=1}^{5} x_{ijk} - \sum_{k=1}^{11} x_{ijk}\ \ for\ 1 \leq j \leq 5$$

Adding the non negativity constraint we will have the following export transshipment model:

$$Min\ TCE = \sum_{j=1}^{5}\sum_{i=1}^{5} c_{ij}x_{ijk} + \sum_{i=1}^{5} c_{ijk}x_{ijk} + \sum_{j=1}^{5} c_{ijk}x_{ijk} + \sum_{k=1}^{11} c_{ijk}x_{ijk}$$

S.T:

$$\begin{cases} \sum_{i=1}^{5} x_{ijk} = MD_j\ for\ 1 \leq j \leq 5 \\ \sum_{j=1}^{5} x_{ijk} = FD_k\ for\ 1 \leq k \leq 11 \\ \sum_{i=1}^{5} x_{ijk} - \sum_{k=1}^{11} x_{ijk}\ \ for\ 1 \leq j \leq 5 \\ \qquad x_{ijk} \geq 0 \end{cases}$$

5.3.2 Imports to Jordan as Transshipment

Imports to Jordan are put in a way that certain middle points will receive the goods from the different world regions and send them to Aqaba. Again, as drawn in the previous export transshipment model, Bombay is chosen as the point to receive goods from the Far East, South West Asia, Australia and New-Zealand and send them to Aqaba; Yanbua is chosen as the second point to receive goods from the Far East, South West Asia, Australia and New-Zealand, Saudi Arabia, Yemen and other Gulf countries, East Africa; Egypt is chosen as the third point to receive goods from North Africa, East Mediterranean, West Europe, East Europe; Europe is chosen as the fourth point to receive goods from West Europe, East Europe, the United States and Canada, the Rest of American countries; America is chosen as the fifth point to receive goods from the United States and Canada, the Rest of American countries and send them all to Aqaba.

Accordingly the Transshipment Import Model to Jordan may look as follows:

Let be x_{ijk} the quantity in tons of the commodity i shipped from place (starting point) k through the midpoint j to the final destination (i.e., Aqaba)

$1 \le i \le 24$ (type of commodity)

$1 \le j \le 5$ (i.e., midpoint destinations)

$1 \le k \le 11$ (starting points)

The objective function is to minimize the total costs of transshipment across the different commodities within the paths, more technically we can formulate:

$$Min\ TCE = \sum_{i=1}^{24}\sum_{j=1}^{5}\sum_{k=1}^{11} c_{kij}x_{ijk} + \sum_{i=1}^{24}\sum_{j=1}^{5} c_{ijk}x_{ijk}$$

c_{kij} is the cost of shipping the commodity i from starting point k to mid point j .

c_{ijk} is the cost of shipping the commodity i coming from the starting point k through midpoint j to final destination Aqaba.

The constraints for the demand at the midpoints for each commodity are:

$$\sum_{k=1}^{11} x_{ijk} \ge MD_{ij}\ for\ i \in \{1, \dots, 24\}\ and\ j \in \{1, \dots, 5\}$$

Where MD_{ij} is the midpoint j demand for the commodity i

The constraints for the demand at the final destination for each commodity are:

$$\sum_{k=1}^{11} x_{ijk} \ge FD_i\ for\ i \in \{1, \dots, 24\}$$

Where FD_i is the final destination's demand for the commodity i

The transshipment constraints are

$$\sum_{k=1}^{11} x_{ijk} - \sum_{j=1}^{5} x_{ijk}\ \ for\ 1 \le i \le 24$$

Adding the non negativity constraint we will have the following imports transshipment model:

$$Min\ TCE = \sum_{i=1}^{24}\sum_{j=1}^{5}\sum_{k=1}^{11} c_{kij}x_{ijk} + \sum_{i=1}^{24}\sum_{j=1}^{5} c_{ijk}x_{ijk}$$

S.T:

$$
\begin{cases}
\sum_{k=1}^{11} x_{ijk} \geq MD_{ij}\ for\ i \in \{1, \dots, 24\}\ and\ j \in \{1, \dots, 5\} \\
\sum_{k=1}^{11} x_{ijk} \geq FD_i\ for\ i \in \{1, \dots, 24\} \\
\sum_{k=1}^{11} x_{ijk} - \sum_{j=1}^{5} x_{ijk}\ for\ 1 \leq i \leq 24 \\
x_{ijk} \geq 0
\end{cases}
$$

6. Methodology

The data for this report has been collected from the ministry of transportation website see (http://www.mot.gov.jo/en/statistics). Whereas the shipping costs were retrieved from different shipping companies. The average of 11 years (1998-2008) from both exports and imports commodities has been obtained to estimate supply and demand quantities for each type of commodity. These averages are used as projections or forecasts for the next period starting from 2009.

The different linear programs were basically resolved by the use of excel solver 2007 by the exception of LP for the importing of commodities to Jordan which was resolved by the use of Risk Premium Solver (http://www.solver.com/platform/risk-solver-premium.htm) which was used instead the ordinary solver of Excel because ordinary solver cannot deal with LP over 200 decision variables. Maritnson (2011) states that "Excel is a powerful spread sheet package used for solving mathematical and business problems".

7. Results Analysis

7.1 Exports Transportation Solution

Table 1. Results of total exported commodities

products / Regions	Phosphate	Fertilizers	Potash	Cement	General Cargo
Far East	247233.95	0	516348.05	0	0
South West Asia	388822.454	0	0	0	563139.54
Australia and New-Zealand	0	0	384268.5	305581.5	0
Gulf countries	687965	0	0	0	0
East Africa	367765	0	0	0	0
North and West Africa	0	0	784998	0	0
West Europe	253054	0	0	0	0
East Europe	390292.455	333382.54	0	0	0
East Mediterranean	686520	0	0	0	0
USA & Canada	0	753142	0	0	0
American countries	594522	0	0	0	0
Total shipment	3616174.859	1086524.54	1685614.55	305581.5	563139.54

The excel solver 2007, is utilized to obtain the optimal solution. This optimality resulted in a total cost of (152087594.5835). Table (1) shows the total exported tonnage of Phosphate (3616174.859), Fertilizers (1086524.54), Potash (1685614.55), Cement (305581.5) and General Cargo (563139.54). Also shown are the shipments of Phosphate to regions (i.e. Australia and New-Zealand, North and West Africa, USA & Canada) resulting in a significant increase of the costs which in return may harm the general policy of transportation. Shipments of Fertilizers to regions (i.e. Far East, South West Asia, Australia and New-Zealand, Gulf countries, East Africa, North and West Africa, West Europe, East Mediterranean, and the Americas) should be cut to avoid affecting the government policies and increasing transportation costs. In regards to Potash it is viewed that in order to reduce transportation costs, it can only be shipped to regions (i.e. Far East, Australia and New-Zealand, North and West Africa). To be more efficient and reduce transportation costs, Cement should only be shipped to Australia and New-Zealand. Finally general Cargo should only be shipped to South West Asia to cut transportation total cost.

The sensitivity analysis shows that the quantities of five exporting products can be reduced by (130000.5955) tons without affecting the optimal policy of Aqaba sea port. Moreover, the same quantity can be increased for each shipment point to keep the same optimal policy.

7.2 Exports Transshipment Solution

To get the best optimal solution, the author utilized excel solver 2007, to solve the export transshipment model developed in section (5.3.1) above. While our expectations were to minimize cost, from a practical point of view, building stocks of commodities in five sites revealed that every location should have a combination of exported commodities. The solution suggests that we should build individual stocks at different locations. This sort of planning is not practical, especially if we know that building will not help supply the regions with commodities. The optimal transshipment costs are higher than both the optimal obtained by the transportation model and the actual total transportation cost of the Jordanian exports to the different regions.

7.3 Imports Transportation Solution

The excel solver 2007, is utilized to obtain the optimal solution. This optimality resulted in a total cost of (121332343.1). As shown in table (2) this optimality shows that the total exported tonnage of Flour (9943), Rice (107254.5), Sugar (150210), Grains (1456401), Vegetable Oil (194439.4), Cars (205662), Steel and Iron (266736), Timber (147567.7), Mineral Oil (20756.5), Ammonia (203474.7), frozen Goods (4048093), Government supplies (67679.7), Tires (854840.5), Sulfur (126999), fertilizers (17812), Gas (471748.7), Live Animals (142556.8), Vegetables & Fruits (210643), Sesame & Beans (35832), Tea/Coffee (3434), Other Goods (22407), and General goods (16182). To cut transportation imports cost, this optimality further shows that Flour should only be imported from United states and Canada. Rice should only be imported from regions (i.e. North & West Africa, East Mediterranean). Sugar should only be imported from regions (i.e. South West Asia, Australia & New-Zealand). Grains should only be imported from regions (i.e. West Europe, East Mediterranean, USA and Canada, American countries). Vegetable Oil should only be imported from regions (i.e. East Europe, East Mediterranean). Cars should only be imported from regions (i.e. Gulf countries, East Mediterranean). Steel and Iron should only be imported from regions (i.e. East Africa, North & West Africa). Timber should only be imported from regions (i.e. Far East, Australia & New-Zealand). Mineral Oil should only be imported from South West Asia. Ammonia should only be imported from regions (i.e. Australia & New-Zealand, Gulf countries, East Europe). Frozen Goods should only be imported from East Mediterranean. Government supplies should only be imported from Gulf countries. Tires should only be imported from East Mediterranean. Sulfur should only be imported from East Europe. Fertilizers should only be imported from North & West Africa. Gas should only be imported from East Mediterranean. Live Animals should only be imported from regions (i.e. East Africa, East Mediterranean). Vegetables & Fruits should only be imported from Gulf countries. Sesame & Beans should only be imported Gulf countries. Tea/Coffee should only be imported from East Mediterranean. Other Goods should only be imported from East Mediterranean. Finally, General goods should only be imported from East Africa. Moreover, excel solver reveals a unacceptable route for importing both Construction Materials and Fodder commodities. This further reveals that any quantity shipped for these two commodities will result in considerable of the total transportation costs.

Table 2. Results of total imported commodities

Regions / Products	Far East	South West Asia	Australia & New-Zealand	Gulf countries	East Africa	North & West Africa	West Europe	East Europe	East Mediterranean	USA and Canada	American countries	Total shipment
Flour	0	0	0	0	0	0	0	0	0	9943	0	9943
Rice	0	0	0	0	0	33197	0	0	74057.5	0	0	107254.5
Sugar	0	67243.5	82966.5	0	0	0	0	0	0	0	0	150210
Grains	0	0	0	0	0	0	396890	0	108407	851316	99788	1456401
Vegetable Oil	0	0	0	0	0	0	0	181448	12991.4	0	0	194439.4
Cars	0	0	0	151504	0	0	0	0	54158	0	0	205662
Steel and Iron	0	0	0	0	44000	222736	0	0	0	0	0	266736
Timber	76977	0	70590.7	0	0	0	0	0	0	0	0	147567.7
Mineral Oil	0	20756.5	0	0	0	0	0	0	0	0	0	20756.5
Construction Materials	0	0	0	0	0	0	0	0	0	0	0	0
Ammonia	0	0	182937.7	10367	0	0	0	10170	0	0	0	203474.7
Frozen Goods	0	0	0	0	0	0	0	0	4048093	0	0	4048093
Government supplies	0	0	0	67679.7	0	0	0	0	0	0	0	67679.7
Tires	0	0	0	0	0	0	0	0	854840.5	0	0	854840.5
Sulfur	0	0	0	0	0	0	0	126999	0	0	0	126999
Fertilizers	0	0	0	0	0	17812	0	0	0	0	0	17812
Gas	0	0	0	0	0	0	0	0	471748.7	0	0	471748.7
Fodder	0	0	0	0	0	0	0	0	0	0	0	0
Live Animals	0	0	0	0	133659	0	0	0	8897.8	0	0	142556.8
Vegetables & Fruits	0	0	0	210643	0	0	0	0	0	0	0	210643
Sesame & Beans	0	0	0	35832	0	0	0	0	0	0	0	35832
Tea/ Coffee	0	0	0	0	0	0	0	0	3434	0	0	3434
Other Goods	0	0	0	0	0	0	0	0	22407	0	0	22407
General Goods	0	0	0	0	16182	0	0	0	0	0	0	16182

This optimal solution for transporting the Jordanian imports is not practical in the sense that it suggests to import only from the nearest regions. Instead of that, it is recommended that Jordan develop its own shipping fleet to cut drastically the cost of importation through means of economics of scale and bulk shipping.

The sensitivity analysis results show that the quantities of the 24 importing products can be reduced accordingly. These quantities are small according to the quantities shipped. For example, Flour commodity can be reduced by 4 tons without affecting the optimal cost. Moreover, the same quantities can be increased for each shipment point to keep the same optimal policy.

7.4 Imports Transshipment Solution

In order to compare what is best for Jordan, the author utilized excel solver 2007, to solve the export transshipment model developed in section (5.3.2) above. The idea is to import from few regional sites rather than dealing with individual countries all over the world. The optimal solution suggested that those regional sites should receive goods from selected countries, which in turn should be sent in bulk to Aqaba, at a total cost of (353738102) which is higher than the optimal obtained by the transportation model. This form of strategy is not practical as it can harm the overall policy.

8. Limitations of the Study

This study is limited, as this study was conducted, data collected through the annual operations financial statements of (1998-2008). Oil prices fluctuated and in some cases inflated as economic (i.e. financial crisis) and political (i.e. international conflict) crisis endured, therefore, affecting the total optimal cost.

9. Conclusions and Recommendations

In order to effectively reduce logistics costs, transportation models play a key role in management and service improvements. In this paper, the author formulates a transportation and transshipment models as a linear programming models for Jordan exports and imports. These models explain the real practice of exporting and importing commodities from different regions in the world.

It is the author recommendations upon analysis that first, Jordan must avoid imports and exports paths that show a null optimal value. Any quantity transshipped or transported along these paths will yield a significant increase in costs which may in return harm the general policy of transportation. Hence harm the government policies and long range plans. This in turn will affect other economic sectors (i.e. Industry, agriculture, and general economic growth).

Second, reduce the quantities of the decision variables (i.e., quantity of products transported or transshipped from the different outlined ports) to the optimal quantities shown in Tables?

Finally, Jordan must define a long term strategy for the different type of products especially in the case of exportation to avoid embarrassing cases similar to the stopping of cement exportations starting from the year 2004 due to the exponential expansion of its use in the huge investments in housing sector. Along this strategy, it is strongly suggested for the government to focus on industry investments to avoid the case of fertilizers where the country is exporting it as raw materials and importing it in turn as finished goods which increases the costs for the country.

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