

GREEN CARGO MOVEMENT SHIFT: EGYPT

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Abstract

There is an issue in the identification of commonality associated with the understanding of cargo movement via different modes of transport other than the road. The approach in this paper considers movement within the Republic of Egypt. A mathematical approach was developed to analyze the impact of cargo movement shifts away from the road transport sector to the greener alternatives of water and rail. The analytical appreciation is considered from the review of large-scale cargo movement across the country. Results from the data analysis are indicative of the impact of an environmentally friendly or a green cargo alternative. The mathematical model described in this paper is used to consider cargo modal shifts under various economic and infrastructure development scenarios. It was the intention during this research to understand the factual situation that road infrastructure currently receives the highest investment priority but the utilization of this additional capacity is not necessarily strong due to less-than-optimum management. The outcome from the analysis results is input into ongoing research to identify common mathematical functions across other jurisdictions besides Egypt. The conclusion is that there is a need for further research to understand whether there is a likelihood that common mathematical models are applicable in other jurisdictions.

Keywords: Egypt, cargo, mode, movement

Introduction

In the world context, almost all cargo movements are dependent on road transport to some extent. For example, the case of the European Union reported (Colliers International, 2016) cargo movement in 2009 was dominated by the road sector. The road modal share for any of the major country members did not fall

below sixty percent. This was even the case in Germany, even though twelve percent of cargo moves via the mode of inland water. The cargo market is still in Germany dominated by road at sixty-five percent. In France, the road cargo modal share is eighty percent increasing to eighty-five percent in the United Kingdom.

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Whilst the modal share in Italy is just over ninety percent. Thus, even in the developed European Union, cargo movement by road transport is a significant mode. This is similar in comparison to developing countries. This dominance of the cargo road sector makes it difficult to realize the objective within the European Union to reduce the dependence on road transport.

The Agenda 2020 of the European Union calls for member countries to reduce greenhouse gas emissions and increase renewable energy (Bartocci and Pisani, 2013). There is implicit in this agenda within the EU of taxing fuels on road-based transport (Bartocci and Pisani, 2013), thus encouraging a modal shift away from the dominant road sector. However, in contrast in many developing countries, there is no fuel tax rather associated with road vehicular movement rather there is a fuel subsidy. The European union agenda provides a possible path for adoption by other nations.

This research and further planned research considers as a comparison of the relative numerical analysis in the determination of cargo generation and modal shift across different localities. This current research considers the cargo movement within Egypt. Although cargo generation is different by locality, the intention is to develop an understanding of the tonnage mode shift to greener efficient modes of transit in different localities. Once a tonne of goods has a

distribution point, what are the factors that will shift this tonne of cargo towards environmentally friendly green transport away from the road sector? There are both network and economic points to consider in this research.

A comparison is problematic across economies of different jurisdictions or localities because different economies produce different goods. However, if cargo movements are considered in broad groups then such an understanding is both possible and plausible. An agglomeration of goods via categories is undertaken using the internationally accepted coding classification of cargo.

The Harmonized Commodity Description and Coding Systems (HS) is an international nomenclature for the classification of products. At the international level, and for commodity grouping, the Harmonized System (HS) for classifying goods is a six-digit code system. For this research, the many cargo classifications identified are combined into an overall five broad groupings roughly these groupings could be considered as agricultural, processed food, chemicals, and minerals, agriculturally derived products such as wood and furs and finally a general or miscellaneous grouping. The five groups are further detailed via their HS numerical system as depicted in (Table 1).

The purpose of the research is to identify within these five groups common trends in the modal shift analysis. The intention is to then

Table 1. Group number relationship to Harmonized Code

Overall Description	First Two Digits of HS Code	Group Number
Animal & Animal Products	01-15	1
Vegetable Products	16-24	1
Foodstuffs	25-27	2
Mineral Products	28-38	3
Chemicals & Allied Industries	39-40	3
Plastics / Rubbers	41-43	3
Raw Hides, Skins, Leather, & Furs	44-49	4
Wood & Wood Products	50-63	4
Textiles	64-67	3
Footwear / Headgear	68-71	4
Stone / Glass	72-83	5
Metals	84-85	5
Machinery / Electrical	86-89	5
Transportation	90-97	5
Miscellaneous	98-99	5

identify common trends and hypothesize the general format of a modal shift first in the incidence of Egypt whilst at the same time identifying the potential impacts on infrastructure requirements which may lead to economic strain within the country.

The economic strain is identified in the size and nature of the required infrastructure. Costing of said infrastructure is not included within the scope of this research. It is, however, possible to identify infrastructure requirements in the form of additional rail track as an alternative to additional km of road space needed in the achievement of green mode shift away from the road sector.

These categorization groupings were a combination of the broader groups developed in an earlier effort for the analysis of goods movement within Egypt (Johnstone and Ratanavaraha, 2017). The original analysis used broader eleven groups. These eleven groups were agricultural products, foodstuffs and animal fodder, solid mineral fuels, petroleum products, ores, and metal waste, metal products, manufactured minerals, and building materials, fertilizers, chemicals, machinery, transport equipment, and manufactured articles and finally live animals. For this research, a decision was made to develop a more composite grouping system combining all cargo into only five groups.

In 2017, it was estimated that 1.6 million tonnes of cargo were moved within Egypt on any given day. Of this tonnage, the major movements were in the categories of agricultural products, construction materials, and machinery with 20%, 39%, and 24% share of total commodity movement respectively.

Literature Review

An important aspect of transport movement that is somewhat neglected when we think of strategic planning (Kölbl *et al.*, 2008) is the movement of cargo. Cargo movement is interwoven with the fabric of the economy, environment, and society, which is linked with the future growth of cargo movement within any locality. Even in the integrated urban

approach of transport planning, (May *et al.*, 2006), the emphasis is often on the movement of people rather than cargo movement. The focus for the urban area is often only limited to urban development (Hollingsworth *et al.*, 1983) and the movement of people between urban areas. However, the research in this incidence has a focus on regional or national cargo transport, not that which is strictly within the boundary of the urban environment. It must be understood that in any interurban travel pattern, the cargo road movements are a significant portion of the road traffic (Hollingsworth *et al.*, 1983).

In the development of this research, the intention is to examine the reality that there is a strategic possibility for green cargo movement. Simply modal shift is achievable and leads in this direction of the movement of cargo away from the dominant road sector. The element of the economy is the linkage to the question of economic strain whereas the society element addresses the question of the cost of achieving a significant green cargo movement. In the regional sense, integration is important as is highlighted as an example in the air sector (Tang *et al.*, 2008). Integration of the road and nonroad sector are important as even when for example cargo is moved mostly by rail, the access to and from the rail is by road.

Overall in the development of any analytical tool for the analysis of the further understanding of movement, transport models are subject to improvement by reference to existing data provided the observed demand flows between localities are robust. If the nature of observed data is not robust, then there are certain issues in using this in the predictive sense (Johnstone and Pretty, 1988). Earlier work (Nemoto, 2009) within a different location namely the Mekong region has highlighted the difficulties in the shifting of cargo from the non-road sector as this is also linked in with logistic chains. In the case of a shipping component within the overall cargo journey, a key is the movement linkage associated with multi-national corporations namely the shipping lines.

In the general question of the modal shift, there is an issue of reliability linked to the

timetabling of both alternatives such as water and rail transport. This has already been highlighted by previous work (De Langen and Sharypova, 2013). It is possible to develop a mathematical model to include consideration of delays at transshipment points including an analysis of an optimum container flow algorithm in modal. The achievement of green transport means that one must realize good intermodal facilities flows between all three key modes of water, rail, and road (Nabais *et al.*, 2015).

The Importance of this Research

An important aspect of transport movement that is somewhat neglected as stated previously when we think of strategic planning (Kölbl *et al.*, 2008) is the movement of cargo. If not neglected, it is not studied in detail. Previously there is limited knowledge in comparison of modal shift and linkage to economic strain including fuel subsidy and the cost of road infrastructure against the opportunity cost for the provision of non- road or greener transport. This research will add to the community knowledge concerning the awareness of the possibilities of achieving a modal shift. Modal shift is important in the light of recent convention that encourages the limitation in the production of greenhouse gas.

The Existing Situation

It is important first to have an appreciation of the existing situation within Egypt. The structure of Egypt's transportation system is presented in (Figure. 1). The current transport infrastructure within Egypt is dominated by a road system that extends over approximately 100,000 km, nearly 23,500 km of which is managed and maintained centrally. This major road network is densest within the Nile Delta, coastal areas, the Sinai Peninsula, and flanking the Nile River which traverses Egypt from north to south. Cairo tends to serve as the “hub” of the national “spoke” of roadways. The road network is varied comprising expressways, toll roads, primary inter-city roads, and other road types. Responsibility for higher-order roads lies mainly with the central government. Within Egypt, some 59,500 km of

paved roadway network is administrated by the country's local administrations.

The rail network extends over some 5,100 km or about 9,600 track km. Almost thirty percent thereof is double-tracked, the remaining network is single-tracked. The entire system is standard gauge and not electrified.

The Inland Water Transport (IWT) network encompasses 2,635 km consisting of 1,696 km within the Nile Valley and 936 km within the Nile Delta. Navigable waterways classified as 1st class require specified vertical clearance, fairway width, maximum draft, and minimum water depth. The First-class network includes 980 km between Cairo and Aswan, 205 km between Cairo and Alexandria as well as 241 km between Cairo and Damietta. These three above-mentioned waterways feature 3 locks and 24 bridges, 7 locks, and 27 bridges, as well as 3 locks and 16 bridges, respectively. About thirty percent of the cargo vessels and ninety percent of the passenger's vessels are owned by the private sector, the remainder being under public sector ownership.

The key movement of cargo within Egypt is the north to south movement corridor from Aswan to the Mediterranean coast. There are three parallel modes available for cargo movement within this corridor namely road,

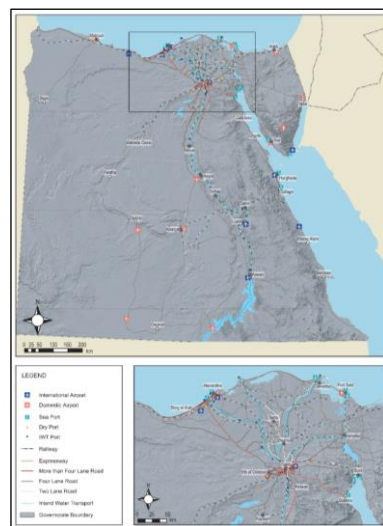


Figure 1. The National transport network

rail, and IWT. The road is currently the dominant transport mode in this corridor.

Methodology

The most commonly used tool for understanding the movement of people or cargo throughout a defined geographical space is a transport model, (Johnstone and Chancharoen 2010). A classic four-step transport model is developed as the analytical tool for the examination of cargo movement throughout the Egyptian region. The structure for understanding movement within the region is built initially from the understanding of the existing observed regional movement from the analysis of an extensive survey program.

Of course, cargo movement does not happen in isolation. Person travel uses the same transport infrastructure as does the movement of cargo. The four-step procedure is followed both for the movement of cargo and people. The cargo procedure is depicted in Figure. 2. The first step determines the size of the trips at each location. The second step proposes the number of trips between locations and estimates short-haul¹ trips whilst step three which is the focus of this research determines the mode of movement. In the second step, short trips are isolated as there is, in fact, no

alternative mode other than the road sector. For this analysis, the key distribution points were the coastal ports and the dry ports.

In the final step, the network assignment combines all movement across all transport network infrastructure. The performance of the road network is defined by both the movement of people and cargo.

Data Analysis

The base input data are a collation of databases available from the government sources held by the various responsible agencies throughout the region. In the case of infrastructure, the master transport network developed in this incidence includes all known transport projects at present, both existing and proposed, that are incorporated into the network with the potential opening year of any new project provided as a network parameter. At the same time, the economic and population datasets are prepared for the base time horizon and a future twenty-year time horizon².

Egypt, the nation was geographically divided into small areas referred to as traffic zones. At the lowest level of detail, the nation was divided into some 385 small areas commonly referred to as traffic zone systems as the basis for model development. A significant survey data program (JICA, 2012) was undertaken for the development of the analytical structure namely some 300,000 roadside interviews^{3,4} at almost 300 locations and some 305 cargo companies across Egypt as further detailed in Table 2.

This dataset provided a base understanding of the existing modal movement of cargo groups between 385 traffic zones. This together with the base economic data allowed for the development of a structured transport model.

The Analytical Structure

The national transport model has, as noted earlier, two distinct streams of

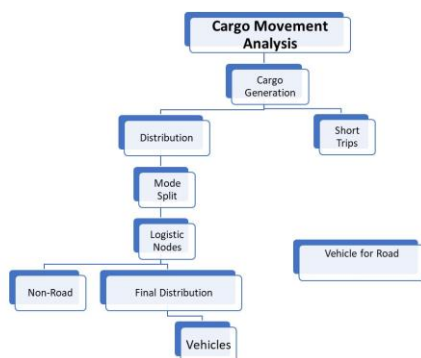


Figure 2. Analytical structure

¹ The proportion of short trips were defined from the analysis of the survey database.

² The twenty-year time horizon is the same time horizon as the official nation vision and national strategy for Egypt.

³ The roadside interview surveys were the key input into the development of the analytical procedure. The overall sample rate was twelve percent. This sample rate is considered sufficient to build a commodity matrix of movement by mode.

⁴ These surveys were a snapshot in time for a single year. Where historical data was available, there was a comparison of traffic growth.

Table 2. Cargo surveys

Survey type	Number of locations	Number of samples
Roadside Interview Survey	185	297,725
Railway Station	26	43,144
Dry Port	4	307
Sea Port	10	16,970
Cargo Forwarder	58	58
Trucking Company	63	63
Manufacturing	242	242

development; namely, for person or passenger transport and cargo or freight transport. The primary purpose of the development of the transport model was the need to understand the requirements for future national transport infrastructure in Egypt. This paper concentrates only on the development of the cargo model stream development. The primary data sources for cargo model development were the survey program briefly described earlier.

Outputs of the person trip model, previous sub-section, are in terms of people by different economic classes. In the cargo modeling context, likewise, the results are a matrix of commodity movements in terms of tonnes instead of people. Additional analysis is required to determine how those tonnes are moved and by what means as is the case with the movement of people.

In the estimation of the movement of cargo, there are four basic steps of generation, distribution, modal choice, and network assignment. The estimation of production and consumption for the five commodity groups previously identified is linked to the elasticity associated with that commodity and the changes in the associated socio-economic parameter either population or regional gross domestic product (GDP). The distribution module calculates the association between trip ends thus identifying the origin and destination of a cargo movement. The next step is the mode distribution which allocates the cargo trips to individual matrix cells by mode. These procedures are estimated for each of the five commodity groups.

The first step in the mode distribution model is to partition the trips into “short-haul”

and “long-haul” trips. The proportion of short-haul trips in the overall national cargo movement is less than ten percent for each commodity group. The modal split model is run on the “long-haul trips”. All short-haul trips are assumed to travel by road. The generalized cost function is defined for each combination of commodity group and mode for each travel zone pair. There are two independent variables associated with the determination of the travel mode between any origin and destination namely time and generalized cost. Each modal cost function includes two coefficients: one for each of the independent variables. For each commodity group, the modal split is a simple multinomial logit model.

The generalized cost of travel between any origin and destination, $\Gamma_{m,c}$ is calculated for each commodity of a group, c moved by mode, m in terms of travel time, the monetary cost of travel⁵ via mode, m . the generalized cost of travel for commodity type c in terms of travel time, $T_{m,c}$ and monetary units, $M_{m,c}$ as defined in Equation (1). The terms, α and β referenced in the equation are the calibration scale factors for travel time and cost respectively. The scale factors for time and cost are tabulated in Tables 3 and 4 respectively.

$$\Gamma_{m,c} = \alpha T_{m,c} + \beta M_{m,c} \quad (1)$$

The mode split by commodity is defined as $\zeta_{m,c}$ for the commodity group, c transported by mode, m in a logit function as detailed in Equation (2). These equations are then programmed into the structure of the transport model.

⁵ Monetary cost and travel time are separate input parameters.

Table 3. Modal split time scale factor

Commodity Group Number	Road	Rail	Inland Water
1	-0.0298	-0.0326	-0.0298
2	-0.0281	-0.0290	-0.0281
3	-0.0452	-0.0452	-0.0452
4	-0.0489	-0.0497	-0.0489
5	-0.0497	-0.0498	-0.0497

Table 4. Modal split monetary scale factor

Commodity Group Number	Road	Rail	Inland Water
1	-0.1007	-0.0490	-0.1007
2	-0.0563	-0.0392	-0.0563
3	-0.0530	-0.0528	-0.0530
4	-0.0901	-0.0767	-0.0901
5	-0.0775	-0.0758	-0.0775

$$\zeta_{m,c} = \frac{e^{r_{m,c}}}{\sum_m e^{r_{m,c}}} \quad (2)$$

This modal split procedure essentially links travel times and modal costs to the proportion of one of five commodity groups carried via the available mode. At the end of the procedure, there are four matrices per commodity group. The “short-haul” trip representing as stated earlier less than ten percent of the tonne movements. Some cargo movements are via intermediate points or logistic nodes. The movement via intermediate points is identified in the next step.

The next and final step is the assignment of movement to the network. The cargo tonnes are allocated to the mode vehicle whether it be a truck, a train, or a barge. The allocation of the truck is particularly inefficient. Truck inefficiency is noted from the survey data that ninety percent of trucks have no backload.

Results and Discussion

This results from the analytical procedure allow for estimation in the base year and for future time horizons. The input into the future time horizon forecast is the improved network

infrastructure and the changing socio-economic parameters. The overall mode split is presented below (Table 5) excluding movements via an extensive national pipeline network. Besides the existing situation, two different twenty-year forecasts are presented here.

The first forecast does not include any significant policy change and thus the road sector remains dominant. This scenario continues the general trend in favoring the road

Table 5. Percentage road mode split

Commodity Group Number	Existing	Twenty Year Forecast	Twenty Year Forecast with Maximum Leverage
1	98.1%	98.0%	80.8%
2	98.9%	99.0%	91.0%
3	98.7%	98.4%	94.1%
4	94.0%	96.8%	87.8%
5	94.6%	96.6%	89.5%

sector. The second twenty-year forecast referred to as the maximum leverage scenario included not only the removal of existing fuel subsidy but also an imposition of fuel tax. In this second scenario, there is a significant change in the operational cost of the road sector. This scenario was aligned with adding additional costs to the road sector.

Such a significant change with its associated change in government policy does not occur overnight but would come to fruition within the timeframe of the twenty-year forecast horizon. The total road proportion of tonne movement in the base time horizon is 97.4%. With the future time horizon, in the case without maximum leverage, the road mode sector is 97.7% whilst in the scenario with maximum leverage, the road mode share is reduced to 91%. The second alternative has a significant impact on the proportion of tonne

movements by road over the twenty-year time horizon.

The implication is that in the case of maximum leverage, the total road mode split share falls by less than an overall 10%. However, the result of the impact of this moderate decrease in the road sector is an

approaching corresponding increase in the non-road sector of nearly five-fold. The non-road sector share of tonne movement has a significant increase. In achieving such a modal shift, this requires a serious evaluation of the existing carrying capability of the non-road sector.

Detail of Discussion

Consideration must be given also to such suggested change by commodity group. In the case of commodity group one, there is a projected 18% decrease in the road sector with a nearly tenfold increase in tonne movements by the non-road sector. For commodity group two, there is a projected 8% decrease in the road sector with a nearly nine-fold increase in tonne movements by the non-road sector. It is important to appreciate that these two commodity groups relate to the movement of bulk agricultural goods and as such is amenable to the movement by rail and IWT.

In the case of commodity group three, there is a projected 4% decrease in the road sector with a nearly four-fold increase in tonne movements by the non-road sector. In the case of commodity group four, there is a projected 9% decrease in the road sector with a nearly four-fold increase in-tonne movements by the non-road sector. For commodity group five, there is a projected 7% decrease in the road sector with a nearly three-fold increase in tonne movements by the non-road sector.

The non-road sector needs improved infrastructure to incorporate the modal shift. There are thus costs associated with the movement of cargo towards a greener future.

Conclusion and Suggestion

When considering the development of new infrastructure in Egypt to assist in the transfer to a green cargo movement, the desired modal split should be pursued in a realistic manner taking the growth trend in road cargo into account. Large increases in the sector capability of the non-road sector are implementable but difficult from a practical and economic point of view.

The twenty-year forecast for the nation demographically per the national vision demonstrates via infrastructure development that it is possible to halt the fact that the road sector for cargo movements was continuing to approach the one hundred percent mark. This is not a good environmental practice (Armstrong-Wright, 1993).

Of course, this is not achievable in the short term. The development of the mathematical model for cargo movement has enabled the transport planner practitioner to advance the understanding of cargo movements and provide a numerical framework for the understanding of the impact.

Further Research

Many issues discussed in this section concerning Egypt are also relevant to the other localities. In this incidence, Egypt is used essentially as the template for the examination of research into the modal shift. This template is now available for localities outside Egypt.

Within Egypt, Modal shift opportunities are apparent as reported in a recent publication. (Johnstone and Ratanavaraha, 2017). There is an opportunity for improved efficiency in regional transport within Egypt via a modal shift. Significant energy subsidies that favor the road sector have in the past made this difficult. In Egypt, transport of cargo by road has been aided by the fuel subsidy which was a little over fifty percent, (Fattouh and El-Katiri, 2013). This implies that when the cost of fuel to the government was one hundred Egyptian pounds, the government was then forward selling to the general public at fifty Egyptian pounds.

Such a subsidy is of course in stark contrast to the status in for example the European Union which imposes a fuel tax. The fuel subsidy in Egypt, however, is not dissimilar to the rest of the Middle East region. In the case of the major oil-exporting countries such as Kuwait or Saudi Arabia, this subsidy approaches ninety percent. In the case of the European Union, taxes on fuel sold within the European Union generally represent between forty and sixty percent of the cost of each liter of fuel, (Klier and Linn, 2013).

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Author Contributions

The author's contributions to the paper are as follows: Leonard Johnstone prepared the original manuscript and sourced the datasets for analysis under the supervision of Vatanavongs Ratanavaraha. Both authors reviewed and approved the final manuscript.

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