

# TRADE AND TRANSPORT TRENDS OF FOOD AND LIVE ANIMAL FOR ASIA-EUROPE-AFRICA

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## **Abstract**

In this paper, food and live animal trade and transportation trends for the three continents of Asia, Europe and Africa, AEA, were analyzed. For the study area a multimodal network was defined and deployed. Using pertinent national spatial socioeconomic data, distribution models reflecting international trade models were developed. The models facilitated identification of possible relations between trade and transportation during four decades covering the period of 1965-2005. Preliminary statistical analyses and gravity modeling determined GDP and transportation variables as more significant factors influencing trade among several database candidate variables. The coefficients of gravity models, reflecting the negative elasticity's of trade with respect to transportation, often showed increasing sensitivity or absolute values through time. During the study period, the comparison between optimal trade distributions, based on linear programming, and their observed distributions, showed significant differences. Further study of the AEA food and live animal trades can enhance trade policy development and resource allocation.

**Keywords:** Food and live animal trade, multimodal transport, trade modeling, gravity modeling, linear programming, Asia, Europe and Africa.

## **Introduction**

Freight transportation plays a key role in trade and economic development. It supports production, trade and consumption activities by ensuring the efficient movement and availability of raw materials, intermediate products and finished goods. Over the years, interest in explicit consideration of commodity and goods movement in the transportation planning has steadily increased (Park and Regan, 2005; Vaziri and Ghadiri, 2012). A recent study suggested that 10% increase in transportation costs would reduce 20% of trade volume (Rodrigue et al., 2009). Transportation cost has a significant effect on final goods' prices, and trade partners are often expected to select the nearest demand and supply nodes. The effect of the transportation distance and cost on trade is a subject of debate as many geopolitical and economic factors can also play significant roles. The continents of Asia, Europe and Africa, AEA, have the advantage of land connectivity and are accommodating more than 80% of world population. Around 90% of total export of European, 79% of Asian and 76% of African countries went to other countries in Asia, Europe and Africa during 2009 (Comtrade, 2010). Higher income, urbanization growth, lifestyle change, globalization, improved transportation and evolving consumer perceptions regarding health, food quality and variability are influencing food consumption patterns. Indeed, increase in import food consumption is one of the consequences of this change (Gehlhar and Coyle, 2001; Regmi, 2001).

The study reported herein tries to shed some light on the effect of transportation on the AEA intra and intercontinental food and live animal trade. The relevant time-series data were extracted from centralized and international databases. The database consisted of variables grouped into 4 categories: food and live animal trade, transportation, geographical and socio-economic characteristics. The study deployed techniques included: preliminary and univariate statistical analysis, regression analysis, shortest path algorithm, elasticity analysis, sensitivity analysis, gravity modeling and linear programming. The international trade flows were analyzed for a 40 year period covering 1965 to 2005. The trans-continental multimodal transportation network covered 125 countries of AEA (Vaziri and Dashtestaninejad, 2010).

## **Database Development**

The study database consisted of pertinent time-series information for international trade extracted from international and centralized databases. It comprised of country's data in 4 categories: food and live animal trade, FAT, transportation, TRS, socio-economic, SEC, and geographical, GEO. The time-series covered a 40 year period of 1965 to 2005. For each year of the study period, 9 variables were finally selected for detail analysis as shown in Table 1. The geographical scope covered 125

countries, 45 in Asia, 31 in Europe and 49 in Africa. The FAT data were extracted from the United Nations Commodity Trade Statistics Division databanks (Comtrade, 2010). The SEC and GEO were also extracted from United Nations databases (Vaziri and Ghadiri, 2012). The TRS data were developed from United Nations sources (Vaziri and Dashtestaninejad, 2010). The AEA multimodal transportation network, with distance and cost attributes, consisted of 5323 nodes, including the 125 capital nodes. Deploying network analysis algorithms, such as shortest path algorithm, TRS variables were determined for capital cities of country pairs  $i$  and  $j$ . The  $C_{ij}^{MM}$  is the optimal transportation cost for the multimodal network which included all the 4 modes of highway, H, railway, R, sea, S and air, A. The  $D_{ij}^{HRS}$  is the optimal distance with 3 modes of highway, H, Rail, R, and sea, S. The  $D_{ij}^{Air}$  is the direct air distance for air mode, A.

No.	Category	Symbol	Unit	Description	Number of cases
1	FAT	$T_{ij}^{EX}$	\$	Export of food and live animal, from country $i$ to country $j$ in dollar	125×125
2		$T_{ij}^{IM}$	\$	Import of food and live animal, from country $j$ to country $i$ in dollar	125×125
3	TRS	$C_{ij}^{MM}$	\$/unit of transport	Multimodal transportation cost between country $i$ and country $j$	125×125
4		$D_{ij}^{HRS}$	Km	Multimodal distance between country $i$ and country $j$	125×125
5		$D_{ij}^{Air}$	Km	Direct distance between country $i$ and country $j$	125×125
6	GEO	$A_i$	Thousand km <sup>2</sup>	Area of country $i$	125
7		$L_i$	Dummy	Landlocked of country $i$	125
8	SEC	$P_i$	Thousand persons	Population of country $i$	125
9		$GDP_i$	\$/year	Gross domestic product of country $i$	125

Table 1: Database structure and description

To shed some light on database structure and scope, preliminary univariate and multivariate statistical analysis was performed. As an example, the summary of preliminary univariate statistical analysis for the year 2005 is presented in Table 2. Furthermore, correlation matrices were developed showing the existence of significant correlation between variable pairs. They often showed significant correlations between trade, GDP and transportation variables. The negative correlations between transportation and trade variables suggested the negative influence of transportation cost and distance on trade.

No.	Var.	Unit	Min	Max	Mean	St. dev.	Coef. of var.	Valid cases
1	$T_{ij}^{EX}$	\$	0	$9.25 \times 10^9$	$2.43 \times 10^7$	$2.17 \times 10^8$	8.96	12648
2	$T_{ij}^{IM}$	\$	0	$7.91 \times 10^9$	$2.41 \times 10^7$	$2.09 \times 10^8$	8.58	12400
3	$C_{ij}^{MM}$	\$/unit of transport	24	7004	2000	991.21	0.49	15500
4	$D_{ij}^{HRS}$	Km	60	18268	6720	3566.85	0.53	15500
5	$D_{ij}^{Air}$	Km	12	14748	5240	2899.47	0.55	15500
6	$A_i$	Thousand km <sup>2</sup>	0.06	17075	678	1794.20	2.65	125

7	$L_i$	Dummy	0	1	0.74	0.44	0.60	125
8	$P_i$	Thousand persons	30	$1.31 \times 10^6$	$4.43 \times 10^3$	$1.55 \times 10^5$	3.50	125
9	$GDP_i$	\$/year	$3.1 \times 10^8$	$4.55 \times 10^{12}$	$2.24 \times 10^{11}$	$6.10 \times 10^{11}$	2.72	123

Table 2: Univariate statistical analysis for year 2005

### Trade Modeling

Several trade modeling approaches can be distinguished: a microscopic level with a microeconomic point of view, a meso level with spatial interaction modeling, and a macroscopic level with a macroeconomic point of view. The spatial interaction modeling approach was found suitable for the study database. The models often used for spatial interaction modeling are based on gravity distribution and linear programming modeling (Vaziri and Ghadiri, 2012).

The gravity model was originated by Newton gravity rule of mechanical physics. The trade gravity model between two countries in its basic form assumes trade increases with country size or incomes and decreases with spatial impedance. After several preliminary gravity modeling trials, to predict FAT trade variables, 3 spatial trade impedance variables of TRS group and GDP were examined in detail by rather simple gravity form as shown by Equation 1:

$$\text{Trade}_{IJ} = d (\text{GDP}_I)^a (\text{GDP}_J)^b / (C_{IJ}^{MM} \text{ or } D_{IJ}^{HRS} \text{ or } C_{IJ}^{Air})^c \quad (1)$$

Where  $\text{Trade}_{IJ}$  variable, trade export or import variable for countries I and J, is determined by calibrating the above model and determining coefficients a, b, c and d, for the countries I and J GDP's and the deployed impedance variable between countries I and J. Deploying multiple regression analysis, logarithmic transformation and a confidence level of 95%, for each year of the study database, trade gravity models were developed. Table 3 shows the elasticity's time trends of the gravity modeling results for 1965 to 2005 for five year intervals for the AEA 125 countries. The FAT and TRS variables are defined as in Table 1.

No.	Model of elasticity absolute value	R <sup>2</sup>	Time trend
1	Elasticity ( $T_{ij}^{EX} / C_{ij}^{MM}$ ) = - 28.551 + 0.0152 ( time )	0.91	Positive
2	Elasticity ( $T_{ij}^{IM} / C_{ij}^{MM}$ ) = - 7.1995 + 0.0043 ( time )	0.63	Positive
3	Elasticity ( $T_{ij}^{EX} / D_{ij}^{HRS}$ ) = - 15.278 + 0.0083 ( time )	0.66	Positive
4	Elasticity ( $T_{ij}^{IM} / D_{ij}^{HRS}$ ) = - 9.8966 + 0.0055 ( time )	0.51	Positive
5	Elasticity ( $T_{ij}^{EX} / D_{ij}^{Air}$ ) = - 9.1894 + 0.0052 ( time )	0.45	Positive
6	Elasticity ( $T_{ij}^{IM} / D_{ij}^{Air}$ ) = - 11.807 + 0.0064 ( time )	0.65	Positive

Table 3: Trade elasticity trends with respect to spatial impedance variables through time

The table confirms the increasing time trend of trade elasticity with respect to TRS impedance variables, as shown by coefficient c of Equation 1. The results of linear regression modeling of Table 3 revealed that the transportation sensitivity of trade has increased over time. This could be of great interest to international organizations and national policy makers to further develop and finance regional transportation infrastructure and facilities. The study rejects the notion of the "death of distance", as some past studies were advocating. The upward trend of distance and cost effect on trade shows the aforesaid hypothesis is not always applicable at least for the food and live animal. In

contrast, AEA countries tried to reduce transportation costs over time by choosing “closer” suppliers of commodities and goods. Nevertheless, through time trade enhancement was far from linear programming, LP, optimal solutions as discussed in the following section.

To determine trade potential improvements, LP, was deployed to compare observed trade distributions with its possible optimal values. The objective function Z, reflecting AEA or continents separately total transportation “cost”, was minimized using simplex algorithm. The LP determined possible redistribution of trade considering trade supply  $O_I$  and demand  $D_J$  constraints of individual countries I and J. Due to language, historical, socio-cultural and geopolitical reasons, it is not always possible to deploy LP solution in actuality; nevertheless it’s solutions provide clues to the potentials for possible improvements. Optimization reflected by relations 2 show the deployed LP problem:

$$\text{Minimize } Z = \sum \sum (C_{IJ}^{MM} \text{ or } D_{IJ}^{HRS} \text{ or } C_{IJ}^{Air}) \text{ Trade}_{IJ} \quad (2)$$

$$\text{Subject to: } \sum \text{Trade}_{IJ} \leq O_I, \sum \text{Trade}_{IJ} \geq D_J \text{ and } \text{Trade}_{IJ} \geq 0 \text{ for all I's and J's}$$

To determine the trends of improvement potentials through time, regression models for AEA and continents separately were developed. Table 4 shows the trends of possible improvement potentials, resulted by LP solutions, for food and live animal trades, for multimodal networks. Equation 3 shows the relation for percent possible potential improvement, PIZ:

$$\text{PIZ} = 100 ( ( Z_{\text{observed}} - Z_{\text{optimum}} ) / Z_{\text{observed}} ) \quad (3)$$

Where  $Z_{\text{observed}}$  is determined from the study database and  $Z_{\text{optimum}}$  is the LP solution of Equation 2. The intra-continental improvement potentials were often more for Europe and Asia than Africa as can be seen from Table 4. Nevertheless, significant trade improvement potentials were observed for all the 125 countries of AEA.

No.	Model of elasticity absolute value	R <sup>2</sup>	Time trend
1	$\text{PIZ} (T_{ij}^{EX}, C_{ij}^{MM})_{\text{AEA}} = -0.1399 (\text{time}) + 319.48$	0.56	Negative
2	$\text{PIZ} (T_{ij}^{IM}, C_{ij}^{MM})_{\text{AEA}} = +0.1431 (\text{time}) - 242.52$	0.73	Positive
3	$\text{PIZ} (T_{ij}^{EX}, D_{ij}^{HRS})_{\text{AEA}} = -0.1972 (\text{time}) + 449.38$	0.69	Negative
4	$\text{PIZ} (T_{ij}^{IM}, D_{ij}^{HRS})_{\text{ASIA}} = +0.1271 (\text{time}) - 216.91$	0.31	Positive
5	$\text{PIZ} (T_{ij}^{IM}, C_{ij}^{MM})_{\text{ASIA}} = +0.2111 (\text{time}) - 393.11$	0.55	Positive
6	$\text{PIZ} (T_{ij}^{EX}, C_{ij}^{MM})_{\text{ASIA}} = +0.2861 (\text{time}) - 538.82$	0.62	Positive
7	$\text{PIZ} (T_{ij}^{EX}, D_{ij}^{HRS})_{\text{ASIA}} = +0.3481 (\text{time}) - 659.53$	0.74	Positive
8	$\text{PIZ} (T_{ij}^{EX}, C_{ij}^{MM})_{\text{EUR}} = +0.0579 (\text{time}) - 84.91$	0.45	Positive
9	$\text{PIZ} (T_{ij}^{EX}, D_{ij}^{HRS})_{\text{EUR}} = +0.1011 (\text{time}) - 169.22$	0.37	Positive
10	$\text{PIZ} (T_{ij}^{IM}, D_{ij}^{HRS})_{\text{EUR}} = +0.011 (\text{time})^2 - 46.55 (\text{time}) + 46198$	0.75	Flat
11	$\text{PIZ} (T_{ij}^{IM}, C_{ij}^{MM})_{\text{EUR}} = +0.006 (\text{time})^2 - 24.82 (\text{time}) + 24665$	0.75	Flat
12	$\text{PIZ} (T_{ij}^{EX}, C_{ij}^{MM})_{\text{AFR}} = -0.513 (\text{time}) + 1031$	0.62	Negative
13	$\text{PIZ} (T_{ij}^{EX}, D_{ij}^{HRS})_{\text{AFR}} = -0.702 (\text{time}) + 1424$	0.61	Negative

14	$PIZ (T_{ij}^{IM}, D_{ij}^{HRS})_{AFR} = - 0.380 (\text{time}) + 786.1$	0.21	Negative
15	$PIZ (T_{ij}^{IM}, C_{ij}^{MM})_{AFR} = - 0.177 (\text{time}) + 368.1$	0.20	Negative

Table 4: Percent possible improvements in trade redistribution

As the table shows, the intra-continental trade improvement potentials for Asia and Europe significantly grew over time compared with Africa, a possible missed opportunity for them as compared with Africa. In other words, Africa showed a convergence of time trend with LP optimal distributions through period of 1965 to 2005. In the contrary, Europe and Asia trades showed divergences of time trend from LP optimal distributions.

### Conclusion

The study shed some light on food and live animal trade trend for three continents of Asia, Europe and Africa, AEA. The trade and transportation among 125 countries, based on spatial interaction models during the period of 1965 to 2005, were assessed and evaluated. The study AEA transportation multimodal network consisted of 5323 nodes connected by highway, railway, air and sea links. The study database consisted of national time-series information for 9 pertinent variables: food and live animal import and export trades between country pairs, multimodal optimal transportation cost between country pairs, multimodal optimal distance between country pairs, air distance between country pairs, GDP, population, area and landlocked. The study deployed techniques included: preliminary statistical analysis, regression analysis, shortest path algorithm, elasticity analysis, sensitivity analysis, gravity modeling and linear programming.

The database preliminary statistical analysis showed significant correlations between trade, GDP, and transportation variables when compared with other variables. Indeed, the developed cross-sectional gravity models confirmed that food and live animal trade between country pairs are related to their GDP's and transportation costs or distances. Elasticity analysis based on the developed gravity models highlighted that the transportation variables seems to play an important role on AEA region trade and this effect is increasing in parallel with globalization trends over time for the whole AEA region, and its 3 continents. This effect is expected to be even more significant in the near future with the current growing trends of energy price and economic crises. Trade elasticity with respect to cost and distance had highest values for Asia and Europe respectively. Africa had lowest transportation sensitivity of trade among studied areas even when trade sensitivity grew significantly over time. The optimal trades, based on linear programming solutions, were compared with observed distributions. Comparison revealed that up to 60% of the AEA total transportation costs can be reduced if the observed trades follow the LP optimal distributions. The differences mostly attributed to the historical, socio-cultural, language, geopolitical, global and other influencing factors that were not considered in this later optimization exercise. Percentage of possible improvement decreased during the study period for Africa. In contrast, percentage of possible improvement for Europe and Asia trade often increased, indicating that observed distributions diverged from the optimums. This study was a preliminary step toward the AEA time-series transportation and trade appraisal. Deploying the study methodology and results can enhance pertinent policy making and infrastructure development at the AEA national and regional levels. The study database and results were limited to extractable information from centralized and accessible international databanks, nevertheless, the same methodology can be used for other geographical and spatial/temporal information to enhance trade and commerce.

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### Biographies

Manouchehr Vaziri is a Ph.D., P.E. and professor of transportation engineering with more than 30 years of teaching and research in different areas of transportation. **Bahador Ghadiri** is a M.S. transportation and logistics engineer at the municipality of the historic city of Esfahan.

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