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Maximizing the economic return from Egypt's export of the most important vegetable crops in the foreign markets

Bader, E. A.* and Dawoud, S. D. Z.

Department of Agricultural Economics, Faculty of Agriculture, Damietta University, Damietta, Egypt.

This study is set to examine the possibility of maximizing the returns of Egyptian vegetable exports: fresh potatoes, onions, and tomatoes, through the optimal distribution of exports to international markets. Linear programming model is formulated to determine the optimal distribution of exports among the importing countries. This model is restricted by export capacity, import capacity, and suggested organization constraints, determining the optimal plan for various scenarios. The mathematical analysis is based on secondary data from the Central Agency for Public Mobilization and Statistics of Egypt and the United Nations Comrade Database for the period of 2010- 2014. The model solution is obtained using the General Algebraic Modeling System (GAMS). The results show that the major export markets for Egyptian potatoes are Russia, Italy, and Germany, representing altogather about 69% of Egyptian exports. For Egyptian onions, Saudi Arabia, Kuwait, Jordan, and Syria together accounted for 77% of the total exported quantity. For Egyptian tomato exports, Syria, Saudi Arabia, Libya, and Iraq accounted for 85% of the total tomatoes exports from Egypt. The results of the various scenarios showed that there is a prospect to increase the Egyptian export returns through geographical re-distribution of exports from potatoes, onions, and tomatoes. Under the capacity of export-import constraints (Scenario No. 1), the total export value would increase by 19.26, 33.95 and 45.30% for potatoes, onions, and tomatoes, respectively. Under countries group constraint (Scenario No. 2), the export value increases by 12.67, 26.49 and 35.85% for these crops, respectively, more than the current export values. Under the suggested model (Scenario No. 3), the export value would increase by 9.56, 25.45 and 25.26% for potatoes, onions, and tomatoes respectively, much more than the current values of exports. Egyptian exports of potatoes would be directed to many countries: the United Kingdom, Greece, Italy and Russia. For onions, higher quantities would be exported to Saudi Arabia, Kuwait, Belgium, and Romania. The most important export markets for Egyptian tomatoes would be Iraq, Italy, Syria, and Saudi Arabia. The study recommends to re-distribute the Egyptian exports of vegetable crops in the international markets to maximize export returns. These models can be used as a tool for the Egyptian decision makers about optimum export distribution for export development.

Key words: Optimal geographic distribution, export development, linear programming, optimization technique.

INTRODUCTION

The Egyptian exports play an important role in economic development especially agricultural exports. Agricultural exports are one of the most important sources to increase the foreign currency. Thus, it is necessary to focus on promoting Egyptian agricultural exports. It is thereby one of the most important pillars of the economy that help to

overcome trade balance deficit. Agricultural exports constitute a proportion of Egyptian total exports, representing about 10.60% of the total exports during the period 2001-2014 (FAOSTAT, 2017). The export of potatoes, onions, and tomatoes is the most important vegetable exports. Therefore, increasing the value of vegetable exports have a significant impact on agricultural export and economic development. Hence, maximizing the return of agricultural export in general and vegetable export in particular is one of the important cornerstone of development.

The total vegetable exports value accounted for USD 969 million representing about 24% of Egypt's agricultural export value as average of the period of 2010 - 2014. Potatoes, onions, and tomatoes export values reached about USD 305, 194, and 43 million representing 31.40, 20.05 and 4.44%, respectively, of the total vegetable export value (UN Comtrade 2016). Despite the low contribution of tomatoes export value in total vegetable export value, its importance comes from the fact of being one of the most essential food commodities as well as acting as a safeguard for many health problem. It is important to understand the actual and optimal distribution patterns of marketed crops to international markets in order to promote Egyptian agricultural exports.

Although Egypt has a comparative advantage in producing vegetable crops, the exporting sector is facing many constraints that are associated with many importing countries differing in export prices and the importing capacity.

Egyptian vegetable exports are spread among more than 25 importing countries in the world, especially for potatoes, tomatoes, and onions. In addition, the fluctuation in exported quantities is resulted in losing Egypt's market share in favor of competing countries. This requires a review of the geographical distribution of vegetable export in different world markets to ensure a share of Egyptian vegetables and maximize the return on export of the same quantity. This needs determining the optimal geographic distribution of vegetables exports especially the most important crops potatoes, tomatoes and onions.

This study mainly aims at optimizing the returns of vegetable export in the importing markets in order to increase the export earnings of Egypt. Specifically, there are three aims to reach. First, understanding the current geographical distribution of export of the most important vegetable crops: fresh potatoes, onions and tomatoes. Second, developing an optimization model to ensure the optimal distribution of export for these crops, and re-distributing of exports for potatoes, onions and tomatoes in different foreign markets to increase the Egyptian

export earnings. This model is to serve as a tool for policy makers of planning in export development. To reach the objective of this study, first is a presentation of the methodology and data with special emphasis on the mathematical model formulation. This is followed by the model results and discussions, along with the overall recommendations.

METHODOLOGY AND DATA

Model specification

The study depends on the descriptive and quantitative methods, using linear programming model to determine the optimal distribution pattern of vegetable exports. Linear Programming (LP) is a mathematical technique used in computer modeling to find the best or optimal solution to resource allocation problems. LP model is a well suited for this study because of the following reasons: (a) many activities and restrictions can be considered at the same time,(b) an explicit and efficient optimum seeking procedure is provided, (c) with a once-formulated model, results from changing variables can easily be calculated, (d) the policy instruments can be incorporated by means of additional or modified activities in the models (Hazell and Norton, 1986). The main components of any constrained LP problem are (Hillier and Lieberman, 2009):

a) **Decision variables** (x_j): Choices available to the decision maker in terms of either inputs or outputs $(\forall\, j=1,...n)$, their values describing the decisions to be made.

b) **Objective function** (z): A mathematical expression of a criterion that is to be maximised (e.g. return) or minimised (e.g. cost) $z = c_1 x_1 + c_2 x_2 + ... + c_n x_n$

c) **Constraints:** A mathematical statement that specifies the elements of the problem such as the restrictions on the values of the decision variables.

$$a_{i1} x_1 + a_{i2} x_2 + ... + a_{in} x_n \le b_1 \quad \forall i=1,...,m .$$

Functional constraints can be also including bounds that are the variables on an optimisation problem permitted to take an infinite range.

d) **Model parameters** $(c_j, a_{ij}, and\, b_i)$: numerical values are determined when the LP model is solved.

LP model is applied to determine the optimal geographical distribution of exports. The General Algebraic Modeling GAMS language is used to calculate the optimum solutions (Brooke et al., 2010; McCarl et al., 2015). It is chosen for this study because of its flexibility and easiness to apply. The linear programming model is used to obtain the optimum geographical distribution of exports. It is designed to maximise total export returns, subject to export-import capacities and organization constraints. The model is based on the

*Corresponding author. E-mail: esbadr@du.edu.eg

expected situation for the Egyptian exports for vegetable crops in world markets. The mathematical formulation of the applied model includes the following components:

The objective function

The objective function is a mathematical expression that combines the decision variables and their coefficients to achieve the goal of maximum export returns. The quantity of the crop to export for importing countries is the decision variable that is to be maximized. The model is to determine the optimal export structure of export for vegetable crops subjected to the limited export and import capacities, and market constraints. It is assumed that the decision maker has a perfect knowledge and that there is no risk (Dawoud, 2014). The objective function is to maximize the value of Egyptian exports. This can be developed as follows:

$$Max Z = \sum_{j=1}^{n} P_j \ X_j \quad \text{where j =1 to n}$$

Z : The total export value of the crop from Egypt,
N: The number of countries,
P_j : Unite value of exported crop from Egypt to importing country j ($/ton),
X_j : The targeted quantity of the crop from Egypt to exports for importing country j (a decision variable) (tons).

Constraints

The constraints are a mathematical expression to address the limit in the model related to supply, demand, and organization constraints. The model identifies possible solutions that respect these constraints in order to achieve the optimum value of objective function. The constraints are represented by the following sets of constraints:

Supply constraint

This set of constraints implies that the sum of export quantities being distributed to countries (decision variables) in a certain period must not exceed or equal the total quantity available to export. The mathematical illustration of the export capacity constraints is presented as follows:

$$\sum_{j=1}^{n} X_j \le EX$$

Where, X_j represents a matrix of the export coefficients (ton) to each importing country j . EX represents the total export quantities of crops from Egypt to the foreign markets in a year.

The total available quantities for the modeling were about 112.87, 348.87 and 61.09 thousand tons for fresh potatoes, onions and tomatoes, respectively representing about 99.22%, 93.58%, and 98.80% of the total exported amounts as average of the years (2010-2014).

Demand constraint

This constraint means that the maximum quantity of exported crop to each importing country i should not exceed its total imported capacity of the country. Assuming that there is no demand increase during a year, demand constraints can be written as:

$$X_j \le IM_j$$

IM is the total import quantity (importing capacity) for each country j.

Organization constraint

The constraint is to ensure the supply of the minimum quantities of export commodities to each market. This suggested constraint is needed for the sake of maintaining export share and keeping stability of exports, and do not losing any market at countries group or country level. At the countries group level, the group export quantities to all countries should not exceed the export quantity in the particular group. The lower limitations on corresponding export quantity are based on the minimum levels of historical quantities exported to each countries group over the period from 2010 t0 2014. This model is to inform policy maker about the impact of economic block markets on exports. The equation for the countries group constraints is formulated as the following:

$$\sum_{i}^{r}\sum_{j}^{n} \alpha_{ij} X_j \ge R_i \quad \forall i =$$

$$Arab\ countries, European\ countries, Asian\ countries$$

Where α_{ij} represents a matrix of the export coefficients (ton) to each importing country j in counties group i . R_i is a vector of the total export quantity available to each countries group i. This minimal as contract with world markets such as Arab market, European market, Asian market. It is modified to suit the Egyptian export conditions and to avoid marketing problems, realizing competitiveness in the world markets.

At the country level: the lower limitations on corresponding export quantity are 50% of the current levels of exported quantity to each country. These organization constraints can be expressed mathematically:

$$X_j \ge L_j$$

Where X_j represents the total export capacity coefficients (ton) to each importing country j . L is the total export quantity available to each country.

Non-negativity constraints

In order to prevent accidental negative values for the decision variables, the following assumption should also be added to the constraints:

$$X_j \ge 0$$

The first two which constraints are obligatory while the organisation constraints are optional. The planner can introduce them to take into account some other limitations such as market constraints. The model is applied in three possible future scenarios in accordance with organization constraints (from Scenario No. 1 to Scenario No. 3) in order to determine the impact of each policy alternative

separately. Scenario No. 1 considers only supply and demand constraints that include first and second constraints, thus providing the impact of export and import capacities constraints on the value of exports. Scenario No. 2 a lower limit over the same period from 2010 to 2014 is placed on the export quantity allocated within each countries group. Scenario No. 3 differs from Scenario No. 2 by limiting the minimum export quantity to be allocated to each country. The lower limit on corresponding export quantity is 50% of the current levels of exported quantity to each country.

RESULTS AND DISCUSSION

Data source

This study is based on data from the Central Agency for Public Mobilization and Statistics (CAPMAS, Unpublished), the National Centre for Information, Egypt, and the United Nations Commodity Trade Database (UN COMTRADE) along with other data and references related to the subject of this study from the internet. For modeling optimization problems the General Algebraic Modeling System (GAMS) is designed (Brooke et al., 2010). Data are entered in familiar list using GAMS. Models are presented in algebraic statements that are easy to read. In the mathematical analysis, the selection of the countries is based on the relative importance of geographical distribution during the period 2010-2014.

Current distribution of Egyptian vegetable exports to international markets

Here presents the current geographical distribution for Egyptian exports of vegetable crops. The current study focuses on exported quantities from fresh or chilled potato, onion, and tomato crops. The exports of these crops are delivered to more than 25 countries in the world. Appendix Table A.1 in the Appendix shows the composition of Egyptian exported crops by importing countries and regions over the period 2010-2014, as follows.

Potatoes

During the period under consideration, EU region was the largest importer of Egyptian potatoes, representing 45.58% of the total Exports. Asian countries ranked second, followed by Arab markets. European countries are mainly restricted to following number of countries: Italy, Germany, Greece, United Kingdom, and Ukraine. More interesting, diverse states namely Italy, Germany, Greece, United Kingdom, Ukraine, Russia, Georgia and Lebanon represented about 87.06% of Egyptian exports for potatoes in 2010-2014. Figure 1 shows geographical distribution for Egyptian exports of Potatoes by major importing countries over the period 2010-2014. The Russian market is one of the most importing Egyptian

fresh potatoes, importing 42.28 thousand tons with relative importance of about 37.20%. The quantity exported to Italian market from fresh potatoes was about 18.44 thousand tons accounted for 16.22% of the total quantity of Egyptian exports over the same period. Germany, Greece, Georgia, Lebanon and United Kingdom were also among the importing countries of potatoes representing about 8.73, 6.05, 5.57, 5.22 and 4.36% of the total potato exports from Egypt during the same period, respectively.

Onions

The Saudi market is one of the significant markets importing Egyptian onions. Table A.1 in the appendix shows the quantity exported to Saudi Arabia from onions is about 182.19 thousand tons representing about 48.87% of the total exported quantity to world markets. Also, Egypt's exports of onions were directed to the markets of Kuwait, Holland, Jordan, Syria, and United Kingdom with share of 5.64, 5.31, 4.29, 4.28 and 3.77% respectively, of the Egyptian onions exports to the foreign markets during the period (2010-2014) (Figure 2).

Tomatoes

During the period (2010-2014), Arab countries were the largest importer of Egyptian tomatoes exports. Appendix Table A.1 in the Appendix shows the geographical distribution of fresh tomato exports to major importing countries. The exported quantity of Egyptian tomatoes to Syria was about 15.54 thousand tons as an average for the period (2010-2014), representing about 25.13% of the total tomato's exported quantity. It was followed by Saudi Arabia (20.38%), Libya (19.84%), and Iraq (13.49%). These top four importers, taken together, accounted for about 78.84% of the total tomato exports from Egypt during the same period. Holland was the biggest importer of Egyptian tomatoes in European market, with a share of 8% of the total Egyptian tomato exports. The rest of the countries share a very small proportion (Figure 3).

Optimal distribution of Egyptian vegetable exports to international markets

The LP model is used to find the optimal distribution pattern of the export crops under study. In order to calibrate the model, the actual distribution plan for the reference average of years 2010-2014 are compared with the results generated by the mathematical models. Tables 1, 2 and 3 compare the optimal values of the total Egyptian export returns and export quantities to international markets in the three scenarios vs. the actual distribution pattern.
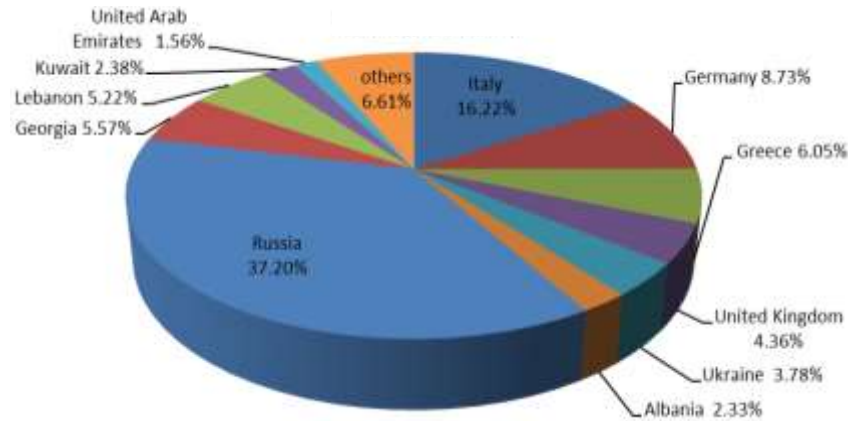
Figure 1. Geographical distribution for Egyptian exports of potatoes during 2010-2014.
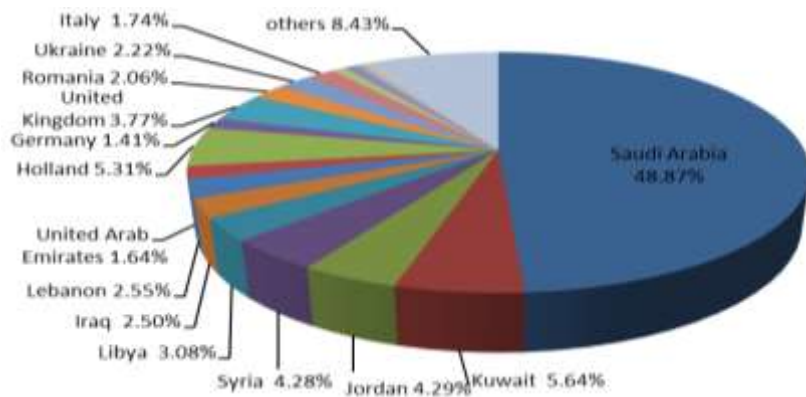
Figure 2. Geographical distribution for Egyptian exports of Onions during 2010-2014
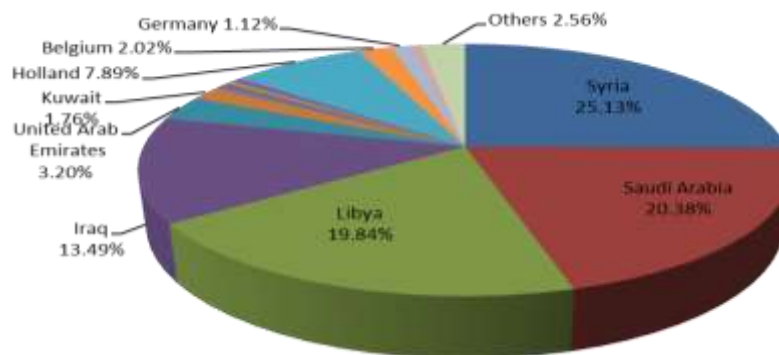
Figure 3. Geographical distribution for Egyptian exports of Tomatoes during 2010-2014

Optimizing the total return for Egyptian potato exports in international markets

Here accounts for optimal scenarios to increase the Egypt's export returns. The results of the LP models are shown in Table 1. The first scenario represents the total exported quantity of potatoes being distributed to high price countries according to imported capacity. It suggests, the total exported quantities distributed to Italy, United Kingdom, Greece and Jordan with shares of

Table 1. Current and optimal geographical distribution for Egyptian exports of potatoes to the international markets, as average during (2010-2014).

Items	Current Plan		Optimal Plans					
			Scenario No. 1		Scenario No. 2		Scenario No. 3	
	Value	%	Value	%	Value	%	Value	%
Export Return ($ million)	52.21	100.00	62.27	19.26	58.71	12.67	57.20	9.56

Suggested Quantity of Exports to Countries (per thousand tons)

Items	Value	%	Value	%	Value	%	Value	%
Italy	18.44	16.34	65.13	57.7	0.00	0.00	9.22	8.17
Germany	9.92	8.79	0.00	0.00	0.00	0.00	5.04	4.47
Greece	6.88	6.10	19.5	17.28	19.5	17.28	19.5	17.28
United Kingdom	4.96	4.39	23.18	20.54	32.15	28.48	14.62	12.95
Ukraine	4.30	3.81	0.00	0.00	0.00	0.00	2.15	1.90
Albania	2.65	2.35	0.00	0.00	0.00	0.00	1.33	1.18
Holland	1.53	1.36	0.00	0.00	0.00	0.00	0.76	0.67
Croatia	1.20	1.06	0.00	0.00	0.00	0.00	0.60	0.53
Bulgaria	0.93	0.82	0.00	0.00	0.00	0.00	0.47	0.42
Romania	0.34	0.30	0.00	0.00	0.00	0.00	0.17	0.15
Kazakhstan	0.50	0.44	0.00	0.00	0.00	0.00	0.25	0.22
Spain	0.20	0.18	0.00	0.00	0.00	0.00	0.10	0.09
Russia	42.28	37.46	0.00	38.22	43.14	38.22	43.14	38.22
Georgia	6.33	5.61	0.00	0.00	0.98	0.87	3.16	2.80
Tajikistan	0.20	0.18	0.00	0.00	0.00	0.00	0.10	0.09
Malaysia	0.13	0.12	0.00	0.00	2.98	2.64	2.34	2.07
Thailand	0.10	0.09	0.53	0.47	0.53	0.47	0.05	0.04
Hong Kong	0.09	0.08	0.00	0.00	1.70	1.51	0.05	0.04
Lebanon	5.93	5.25	0.00	0.00	5.58	4.94	2.96	2.62
Kuwait	2.70	2.39	0.00	0.00	0.00	0.00	1.35	1.20
United Arab Emirates	1.77	1.57	0.00	0.00	1.77	1.57	0.88	0.78
Amman	0.61	0.54	0.00	0.00	0.00	0.00	0.31	0.27
Syria	0.32	0.28	0.00	0.00	0.00	0.00	0.16	0.14
Jordan	0.26	0.23	4.08	3.61	4.08	3.61	4.08	3.61
Bahrain	0.30	0.27	0.45	0.40	0.46	0.41	0.08	0.07
Total	112.87	100.00	112.87	138.22	112.87	100.00	112.87	100.00

Source: Mathematical programming models results based on Comtrade data and CAPMAS, various Issues.

57.70, 20.54, 17.28 and 4.08%, respectively, because of their high export prices. Under this scenario, the total export returns are increased by 19.26% above the actual total returns.

Scenario No. 2 maximizes the value of Egyptian potato exports subject to countries group constraint. The constraint is to ensure the supply of the minimum quantities of export commodities for each countries group during 2010-2014. These countries were Arab countries, European countries, Asian countries. European countries were the largest importer of Egyptian export potatoes, representing 51.56% followed by Asian countries (49.33%) and Arab countries constituting (10.53%) of the total potato exports from Egypt during 2010-2014. The largest increase in exported potatoes will be to the United Kingdom, Greece, Russia, and, Jordan. There is a potential to generate an estimated export returns

equivalent to about 12.67%, that exceed the current export returns. Scenario No. 3 assumes that the lower exported quantity of potatoes to each country is 50% of the actual exported quantity. The most important countries, which appear in the model results include United Kingdom, Greece, Russia, and Jordan. Egypt's potato exports will increase in countries like the United Kingdom and Jordan. The other countries will remain at minimum levels. The scenario No.3 generates a high export returns about US $57.20 million equivalent to almost 9.56% exceeding the actual total export returns.

Optimizing the total return for Egyptian onion exports in international markets

The results of the LP models for onions exports are

Table 2. Current and optimal geographical distribution for Egyptian exports of onions to the international markets as average during (2010-2014).

Items	Current Plan		Optimal Plans					
			Scenario No. 1		Scenario No. 2		Scenario No. 3	
	Value	%	Value	%	Value	%	Value	%
Export Return ($ million)	177.63	100.00	237.94	33.95	224.69	26.49	222.83	25.45
Suggested Quantity of Exports to Countries (per thousand tons)								
Saudi Arabia	182.19	52.22	0.00	0.00	0.00	0.00	91.02	26.09
Kuwait	21.01	6.02	88.01	25.23	88.01	25.23	88.01	25.23
Jordan	15.99	4.58	0.00	0.00	70.78	20.29	7.77	2.23
Syria	15.94	4.57	0.00	0.00	0.00	0.00	8.07	2.31
Libya	11.49	3.29	0.00	0.00	83.59	23.96	5.87	1.68
Iraq	9.33	2.67	0.00	0.00	0.00	0.00	4.69	1.34
Lebanon	9.52	2.73	0.00	0.00	0.00	0.00	4.84	1.39
United Arab Emirates	6.11	1.75	0.00	0.00	14.49	4.15	3.05	0.87
Amman	2.01	0.58	0.00	0.00	19.16	5.49	1.02	0.29
Bahrain	2.09	0.60	0.00	0.00	0.00	0.00	1.04	0.30
Tunis	0.35	0.10	0.00	0.00	0.00	0.00	0.17	0.05
Holland	19.8	5.68	0.00	0.00	0.00	0.00	9.90	2.84
Germany	5.27	1.51	0.00	0.00	0.00	0.00	2.60	0.75
United Kingdom	14.04	4.02	15.40	4.41	15.41	4.42	15.40	4.41
Romania	7.67	2.20	39.26	11.25	0.00	0.00	30.3	8.69
Ukraine	8.26	2.37	0.00	0.00	0.00	0.00	4.13	1.18
Italy	6.50	1.86	141.07	40.44	0.00	0.00	3.30	0.95
Belgium	2.88	0.83	61.06	17.5	53.36	15.30	61.06	17.50
Greece	2.99	0.86	3.23	0.93	3.23	0.93	3.23	0.93
Cote d'Ivoire	1.34	0.38	0.00	0.00	0.00	0.00	0.67	0.19
France	1.07	0.31	0.00	0.00	0.00	0.00	0.52	0.15
Bulgaria	0.87	0.25	0.00	0.00	0.00	0.00	0.44	0.13
Albania	0.71	0.20	0.00	0.00	0.00	0.00	0.35	0.10
Cyprus	0.67	0.19	0.00	0.00	0.00	0.00	0.37	0.11
Croatia	0.41	0.12	0.00	0.00	0.00	0.00	0.21	0.06
Slovenia	0.36	0.10	0.84	0.24	0.84	0.24	0.84	0.24
Total	348.87	100.00	348.87	100.00	348.87	100.00	348.87	100.00

Source: Mathematical programming models results based on Comtrade data and CAPMAS, various Issues.

shown in Table 2. The first scenario suggests that the total exported quantities distributed to Italy, Kuwait, Belgium, Romania and United Kingdom with a share of 40.44, 25.23, 17.50, 11.50 and 4.41% respectively more than the actual export returns, because of their high export prices. This optimum distribution has been coupled with about 33.95% increasing in the total export returns compared to the current situation.

Scenario No. 2 maximizes the value of Egyptian onion exports subject to countries group constraint. Arab countries were the largest importer of Egyptian onion exports, representing about 79% of total Egyptian exports, followed by European countries (21%) of total onion exports from Egypt during 2000-2014. Egyptian onions would be exported to many countries of the world: Kuwait, Libya, Jordan, Belgium, Amman, United Arab

Emirates and United Kingdom. The results indicate that the total export returns are increased by 26.49% more than the actual total export returns. For scenario No. 3, the export quantities to Saudi Arabia, Kuwait, Belgium and Romania will increase with a share of 26.09, 25.23, 17.50 and 8.69% of total Egyptian onion exports. The other countries will remain at minimum levels. Scenario 3 generates a high export returns about US $ 222.83 million equivalent to nearly 25.45% more than the actual total export returns.

Optimizing the total return for Egyptian tomato exports in international markets

As shown in Table 3, the first scenario suggests the total

Table 3. Current and optimal geographical distribution for Egyptian exports of tomatoes to the international markets, as average during (2010-2014).

Items	Actual Plan		Optimal Plans					
			Scenario No. 1		Scenario No. 2		Scenario No. 3	
	Value	%	Value	%	Value	%	Value	%
Export Return ($ million)	40.39	100.00	58.70	45.30	54.87	35.85	50.74	25.63
Suggested Quantity of Exports to Countries (per thousand tons)								
Syria	15.54	25.44	0.00	0.00	0.36	0.59	7.56	12.38
Saudi Arabia	12.6	20.63	0.00	0.00	0.00	0.00	6.78	11.10
Libya	12.27	20.09	0.00	0.00	0.00	0.00	5.61	9.18
Iraq	8.34	13.65	22.00	36.01	22.00	36.01	22.00	36.01
United Arab Emirates	1.98	3.24	0.00	0.00	3.73	6.11	1.03	1.69
Kuwait	1.09	1.78	0.00	0.00	25.55	41.82	0.54	0.88
Qatar	0.35	0.57	0.00	0.00	0.00	0.00	0.17	0.28
Amman	0.25	0.41	0.00	0.00	1.37	2.24	0.12	0.20
Yemen	0.17	0.28	0.00	0.00	0.00	0.00	0.09	0.15
Morocco	0.42	0.69	0.00	0.00	0.00	0.00	0.21	0.34
Holland	4.88	7.99	0.00	0.00	0.00	0.00	2.44	3.99
Belgium	1.25	2.05	0.00	0.00	0.00	0.00	0.60	0.98
Germany	0.69	1.13	0.00	0.00	0.00	0.00	0.26	0.43
Italy	0.42	0.69	36.39	59.57	5.38	8.81	10.52	17.22
United Kingdom	0.37	0.61	0.00	0.00	0.00	0.00	0.25	0.41
Turkey	0.15	0.25	0.00	0.00	0.00	0.00	0.08	0.13
Denmark	0.14	0.23	0.00	0.00	0.00	0.00	0.07	0.11
Hungary	0.12	0.20	0.00	0.00	0.00	0.00	0.06	0.10
Slovenia	0.06	0.10	2.70	4.42	2.70	4.42	2.70	4.42
Total	61.09	100.00	61.09	100.00	61.09	100.00	61.09	100.00

Source: Mathematical programming models results based on Comtrade Data and CAPMAS, various issues.

exported quantities distributed to Italy and Iraq with a share of 59.57 and 36.01%, respectively, of the total Egyptian exports. This could be as a result of high export prices. Under this scenario, the total export returns are increased by 45.30% above the actual total returns. Scenario No. 2 maximizes the value of Egyptian tomatoes exports subject to countries group constraint. Arab countries are the largest importer of Egyptian tomato exports, representing 86.87% of the total Egyptian exports. The Scenario shows that the total returns are increased by 35.85% above the actual total net returns. The results of scenarios 3 show that the minimum level is considered by 50% of the actual levels of export quantity to each country. Iraq was largest importer of Egyptian tomato exports, representing 36.01% followed by Italy, (17.22%), Syria (12.38%), and Saudi Arabia (11.10%) of total Egyptian potatoes exports during 2010-2014. The other countries will remain at minimum levels. The results indicate that there is a prospect to generate an estimated export returns equivalent of US $ 50.74 million representing about 25.63% more than the actual total export returns.

Conclusions

Regarding the results of the above analysis, the major potato export markets are Russia, Italy, Germany, Greece, and Lebanon representing about 82% of Egyptian exports from potatoes. The most important countries that import Egyptian onions are: Saudi Arabia, Kuwait, Jordan and Syria accounting together for 77% of total quantity exported to the world markets. Arab countries were the largest importers of Egyptian tomato exports. The top four importers Syria, Saudi Arabia, Libya and Iraq, together representing about 85% of total tomato exports from Egypt.

Based on the results of the suggested mathematical model to explore optimal distribution pattern for vegetable exports, the following conclusions could be deduced:

i) There is a likelihood for improvement in total returns to Egyptian vegetable exports through the optimum geographical re-distribution of crop exports.
ii) The largest increase in Egyptian fresh potato exports will be to United Kingdom, Greece, Russia, and, Jordan.

iii) The most important countries where higher export quantities of Egyptian onions are involved Saudi Arabia, Kuwait, Belgium and Romania.

iv) The most important import markets for Egyptian tomato exports are Iraq followed by Italy, Syria, and Saudi Arabia.

RECOMMENDATIONS

Several recommendations would be made for the future export development policies in Egypt as follows:

i) Producers should be advised to produce high value export crops and increase their production to meet the growing foreign demand.

ii) Government should encourage investment in production projects for export and improve distribution export pattern.

iii) Maintaining Egypt's position of vegetable exports in the actual international markets to meet their needs with the required quality of crops.

iv) The applied mathematical models can be used to provide information to decision makers about likely optimal distribution policy alternatives for export development.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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APPENDIX

Table A1. The geographical distribution for the Egyptian exports of potatoes, onion and tomatoes to the different foreign markets, for average (2010-2014).

Potatoes			Onions			Tomatoes		
Countries	Quantity of Exports	%	Countries	Quantity of Exports	%	Countries	Quantity of Exports	%
Italy	18.44	16.21	Saudi Arabia	182.19	48.87	Syria	15.54	25.13
Germany	9.92	8.72	Kuwait	21.01	5.64	Saudi Arabia	12.6	20.38
Greece	6.88	6.05	Jordan	15.99	4.29	Libya	12.27	19.84
United Kingdom	4.96	4.36	Syria	15.94	4.28	Iraq	8.34	13.49
Ukraine	4.30	3.78	Libya	11.49	3.08	United Arab Emirates	1.98	3.20
Albania	2.65	2.33	Iraq	9.33	2.50	Kuwait	1.09	1.76
Holland	1.53	1.34	Lebanon	9.52	2.55	Qatar	0.35	0.57
Croatia	1.20	1.05	United Arab Emirates	6.11	1.64	Amman	0.25	0.40
Bulgaria	0.93	0.82	Amman	2.01	0.54	Yemen	0.17	0.27
Romania	0.34	0.30	Bahrain	2.09	0.56	Morocco	0.42	0.68
Kazakhstan	0.50	0.44	Tunis	0.35	0.09	Arab countries	53.01	85.74
Spain	0.20	0.18	Arab countries	276.03	74.04	Holland	4.88	7.89
European countries	52.82	45.58	Holland	19.8	5.31	Belgium	1.25	2.02
Russia	42.28	37.17	Germany	5.27	1.41	Germany	0.69	1.12
Georgia	6.33	5.56	United Kingdom	14.04	3.77	United Kingdom	0.42	0.68
Tajikistan	0.20	0.18	Romania	7.67	2.06	Italy	0.37	0.60
Malaysia	0.13	0.11	Ukraine	8.26	2.22	Turkey	0.15	0.24
Thailand	0.10	0.09	Italy	6.5	1.74	Denmark	0.14	0.23
Hong Kong	0.09	0.08	Belgium	2.88	0.77	Hungary	0.12	0.19
Asian countries	49.08	43.19	Greece	2.99	0.80	Slovenia	0.06	0.10
Lebanon	5.93	5.21	Cote d'Ivoire	1.34	0.36	European countries	8.08	13.07
Kuwait	2.70	2.37	France	1.07	0.29	Others	0.74	1.20
United Arab Emirates	1.77	1.56	Bulgaria	0.87	0.23	World	61.83	100.00
Amman	0.61	0.54	Albania	0.71	0.19			
Syria	0.32	0.28	Cyprus	0.67	0.18			
Jordan	0.26	0.23	Croatia	0.41	0.11			
Bahrain	0.30	0.26	Slovenia	0.36	0.10			
Arab countries	11.41	10.45	European countries	72.84	19.54			
Others	0.89	0.78	Others	23.94	6.42			
World	113.76	100.00	World	372.81	100.00			

Source: Based on data from CAPMAS and Comtrade, for the period 2010 to 2014.