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Clustering potential of Istanbul maritime sector

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Abstract

Purpose – Turkey is a maritime country with its current merchant fleet and shipyards, geographical location, young population and growth potential. Clustering, being one of the important improvement methods of global competition power, is widely used in the maritime sector. Analysing the clustering level and potential of Istanbul, which is the major city of Turkey, in regard to economic and social aspects is a basic step for increasing global competitiveness in this sector. This study aims to measure the clustering level of Istanbul's maritime sector and also define the effect of clustering level on firm performance.

Design/methodology/approach – The clustering levels of Istanbul's maritime transportation and supporting firms, shipyards and maritime equipment manufacturers are measured by means of a survey based on Porter's diamond theory in this paper. The relationship between clustering level and firm performance is defined by using simple linear regression and fuzzy linear regression methods. The weights of the criteria are calculated by means of entropy method.

Findings – It is concluded that despite its deficits, Istanbul's maritime sector has significant potential to become a major maritime cluster not only in its region but also worldwide. The effect of clustering level on firm performance was observed to be statistically significant, but not high. The results of the simple linear regression and fuzzy linear regression methods are compared.

Originality/value – According to the author's knowledge, this paper is the first study using fuzzy linear regression and entropy methods to analyse maritime clusters. It evaluates the effect of clustering level on firm performance in the case of Istanbul maritime sector.

Keywords Competitiveness, Entropy, Regression analysis, Fuzzy linear regression, Istanbul maritime sector, Maritime clusters

Paper type Research paper

1. Introduction

Today, it is widely accepted that accelerating globalisation and liberalisation have erased geographical boundaries and decreased the importance of national and local competitiveness. On the other hand, some researchers often state that local, national and regional geography still have a very high impact in terms of competition on economic activities throughout the globe. Geographical concentration, also termed agglomeration or clustering of industries via high level cooperation between firms and related organisations in a certain area, accelerates national competitiveness in a very positive way (Porter, 1990; Saxenian, 1996; Roelandt and den Hertog, 1999; Rosenfeld, 2003; Enright, 2003).

Clustering is a global competition tool which is used not only by industrial sectors but also by service sectors such as logistics, maritime transportation and ports. This study assesses the Istanbul maritime sector by using the cluster approach. First, the definition of a cluster will be made and Porter's Diamond Theory will be explained. In Section 2, literature regarding maritime clusters will be summarised. Section 3 will generally describe the Turkish maritime sector and Istanbul as a maritime city. In the Section 4, the quantitative

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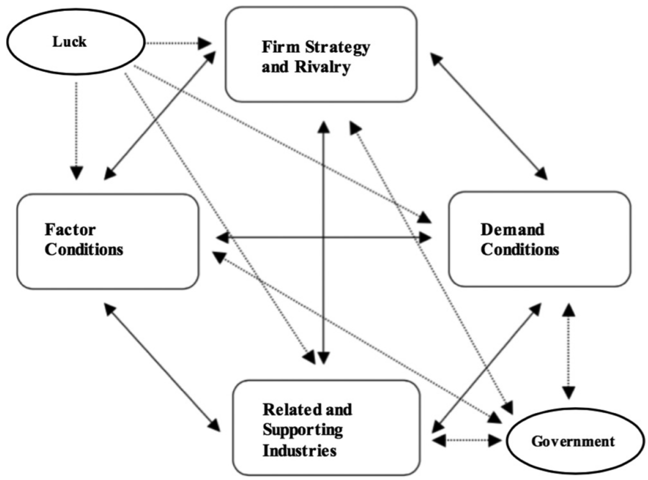
analysis of the clusters method used in this study will be explained, and in Section 5, the potential of Istanbul's maritime cluster will be analysed and empirical results discussed. Section 6 will conclude the study.

1.1 What is a cluster?

A cluster is a geographically proximate group of interconnected companies and associated institutions (e.g. firms, specialised suppliers, supplementary organisations such as associations, universities and R&D corporations) in a particular field, linked by commonalities and complementarities. They cooperate with each other without giving up their independence, in other words being in coopetition they strive to gain local, national, regional and global competitive strength (Porter, 1990). Roelandt and den Hertog (1999) define a cluster as a network of interrelated firms, institutions of knowledge, buyers and sellers, suppliers, etc. Rosenfeld (2003) defines a cluster as an agglomeration of firms which can create synergy, and Enright (2003) also defines the cluster as an agglomeration in which the member firms have very close relations.

Porter has focussed his research on the competitiveness of different countries throughout the globe and tried to answer the following question: "Why are some of these countries more competitive?". He has based his "Diamond Model" on the interrelationships of various factors such as factor (input) conditions, demand conditions, firm strategy and rivalry and related and supporting industries. The Diamond model explains briefly the relationships between these corners of the diamond as well as the outside effects of government and luck (Figure 1).

There are two dimensions of Porter's cluster definition. The first is the existence of the network relationships between firms. These relations occur in two ways: vertical (input-output relations with forward and backward linkages) and horizontal (the relations among firms which produce complementary products/services and which use common specialised factor conditions such as technology and workforce). Most of these links consist of social relationships and networks among firms, and they create the benefits of clusters. The second dimension is the geographical closeness of the firms within clusters. Porter has



Source: Porter (1990, 2008)

Figure 1. Porter's Diamond Model

emphasised the critical role of co-location with his cluster definition. This closeness would be a network of relations in a particular portion of a city, an entire city, a region, a country or crossborder cooperation of multiple countries. Clusters are the networks of those firms and institutions creating synergy in a common geography (Porter, 2000, 2008).

1.2 Benefits of clusters

Porter lists the benefits of clusters as follows:

- increasing innovation-based new forms of business models providing productivity and employment growth;
- facilitating access for specialised inputs and supplies with a high advantage against non-members of the cluster;
- improving coordination among firms in the cluster which helps coopetition, knowledge and experience sharing, common R&D and benchmarking;
- introducing new products and services through highly capable sub-contractors and innovation; and
- facilitating access for government subsidies, technology pools and financial tools (Porter, 2000).

2. Maritime clusters

Service sector clusters are not as prevalent as industrial clusters, but nevertheless, many studies have been conducted in this area. Maritime clusters, locating maritime transportation sub-sector at their cores, are good examples for these kinds of service sector clusters. Mainstream research about maritime clusters focuses on the maritime sector as a whole and its interrelation with the country's competitiveness, but more specific clustering studies in sub-sectors such as ports and shipbuilding are also available. As for the maritime nations, regions or the cities with strong maritime clusters, one can easily observe that Norway is the leading country in the area due to its highly integrated, well-coordinated and technologically structured innovative maritime industry in close relationship and cooperation. London is another example for well-established and developed maritime clusters owing to its highly expertised maritime services sector in global dimensions. Also, there is the South Korea ship building cluster, with its skilled and hardworking labour force as well as Singapore and The Netherlands port clusters with their efficient and high capacity ports in Southeast Asia and Western Europe, respectively.

The literature regarding maritime clusters contains many case studies from European maritime countries such as Norway (Benito *et al.*, 2003; Fløysand *et al.*, 2012), The Netherlands (De Langen, 2002), the UK (Chang, 2011, 2012), Ireland (Brett, 2007; Morrissey and O'Donoghue, 2013; Morrissey and Cummins, 2016), Finland (Laaksonen and Makinen, 2013), Portugal (Salvador *et al.*, 2016) and Lithuania (Viederyte, 2014a, 2014b) and as well as from maritime countries throughout the globe including China (Deng *et al.*, 2013), Japan (Shinohara, 2010), Panama (Pagano *et al.*, 2012; Pagano *et al.*, 2016), Canada (Doloreux and Shearmur, 2009; Doloreux *et al.*, 2015) and Malaysia (Othman *et al.*, 2011).

The motives for the sectoral organisation via clusters are availability of labour pool, widespread supplier and customer base, knowledge spillovers, increase in innovation and low transaction costs (De Langen, 2002; Pinto *et al.*, 2015). A good maritime cluster provides appropriate consulting and management, improves connections among firms, universities and research institutions, increases data sharing and facilitates sub-structure and financial aids to the sector (Chang, 2011; Othman *et al.*, 2011; Salvador *et al.*, 2016).

To establish a properly functioning maritime cluster; state aid at the initial phase is vital (Shinohara, 2010). Also integrated maritime policies based on healthy statistical data is a key to gaining a global competition advantage (Wijnost, 2006). For the success of the maritime clusters, there is an on-going discussion about whether a topside-down or bottom-up approach is more effective (Fløysand *et al.*, 2012; Chang, 2012). Deficiency of leader firms in the maritime sector requires a topside-down approach. Developed countries have the advantage while establishing maritime clusters because of their high number of leader firms which have some multiplier effects. These firms in a maritime cluster could create some benefits for the entire cluster by engaging in structural R&D and innovation and by accessing international markets and international knowledge as well (De Langen, 2002).

There are four types of maritime clusters:

(1) maritime clusters involved in shipping and port operations with mainly cargo loading and discharging functions [e.g. Dublin (Ireland) (Brett, 2007)];

(2) the maritime cluster is the centre for cargo allocation and value-added processing [e.g. Osaka (Japan)];

(3) the maritime cluster is a supply chain hub in the global/regional economic and trade market [e.g. Rotterdam (The Netherlands) (De Langen, 2002)]; and

(4) the maritime cluster has the knowhow and workforce expertise, upon which the international maritime services (ship finance, maritime law, marine insurance, ship registry, ship chartering and ship brokering) depend [e.g. London (UK) (Brownrigg, 2006)] (Zhang and Lam, 2013).

A maritime cluster has a life cycle, so once it has been established and developed, feedback loops should be used to reconstruct the cluster for sustainability (Fløysand *et al.*, 2012).

As for the Turkish maritime sector, some sub-sectoral research does exist, including a SWOT analysis of Istanbul's maritime transportation sector (Deval and Saman, 2005), a model proposal for the Turkish maritime cluster taking the EU as an example (Gurbuz, 2008) and a partnership between military and civilian shipbuilding technologies forming a cluster to build military vessels (Akincilar Tan, 2011).

3. Turkish maritime sector and the role of Istanbul as a maritime city

Regarding the global economic environment which is highly dependent on maritime transportation, the current status of the Turkish maritime sector is not in good condition in proportion to its high economic, demographic and geographic potential. According to 2017 data (January 1, 2018 and greater than 1000 GT), the Turkish-owned national and international maritime fleet comprised 1,511 ships, 28,611,000 DWT and 277,000 TEU capacity. The sum of the Turkish-owned maritime fleet is ranked 15th in the World by tonnage (Chamber of Shipping, 2018). The Turkish-owned maritime fleet in numbers and tonnage has grown significantly, despite the adverse effects of the 2008 global financial crisis.

Turkey has 180 ports, mostly operated by the private sector, on its coastline. These ports have a theoretical capacity of 600,000,000 tons and 25,543,028 TEUs. In 2017, 73,306 ships called into Turkish ports and handled 471,173,896 GT and 10,010,537 TEU of cargo (Chamber of Shipping, 2018).

There are 78 shipyards in Turkey, mostly located in the Marmara Sea and western Black sea coasts. Approximately 30,000 people are working in the shipbuilding sector. In 2017, the number of delivered vessels was 21 and their total tonnage was 98,940 DWT. (This tonnage was 962,072 DWT in 2008). This sub-sector has been affected very badly by the 2008 global economic crisis, but it is trying to recover today (Chamber of Shipping, 2018).

Istanbul is the most developed city of Turkey in social and economic aspects. Half of the Turkish maritime sector firms are located in Istanbul. According to records of the Chamber of Shipping, approximately 4,000 of 8,000 Turkish maritime firms are located in Istanbul. Most of the Turkish flag ships' homeports is Istanbul. Most of the ship owners, shipping firms and supporting services are located in Istanbul. Finally, the centres of Turkish shipbuilding and yacht manufacturing sectors are in Istanbul. Thus, any clustering effort in the Istanbul maritime sector will affect the Turkish maritime sector as a whole.

In this context, clustering can be one of the most effective methods to make the Istanbul maritime sector globally more competitive. The measuring of the current clustering condition and potential of Istanbul's maritime sector through qualitative and quantitative tools is the first step of such an endeavour. After measuring these variables and determining the cluster's level, its classification, current stages of its life cycle, competitive advantages/disadvantages, dimensions of the network relations, potentials, innovation capacities, abilities to create added value, etc., would be stated. Following this, the findings would be transformed into a clustering model for the Istanbul maritime sector in the light of successful maritime cluster examples through the globe.

4. Methodology

Maritime cluster studies mostly use descriptive, statistical and mixed methods based on Porter's diamond model. Case studies of maritime sectors of some cities, areas or countries, which have used primary data from interviews and surveys supported by statistical secondary data, are very common in the literature (Benito *et al.*, 2003; Deval and Saman, 2005; De Langen, 2005; NG, 2006; Finckenhagen and Fjeld, 2008; Shinohara, 2010; Othman *et al.*, 2011; Laaksonen and Makinen, 2013; De Langen, 2013; Makkonen *et al.*, 2013; Teijl, 2014; Ulvin, 2014; Doloreux *et al.*, 2015). Several descriptive studies solely based on secondary data also exist (Deng *et al.*, 2013; Lam *et al.*, 2013; Viederyte, 2014a; Viederyte, 2014b; Gunther, 2014). An input-output approach is also used to analyse maritime clusters, but it requires a great deal of sound statistical data regarding the forward-backward linkages of the maritime sectors (Pagano *et al.*, 2012; Morrissey and O'Donoghue, 2013; Morrissey and Cummins, 2016; Salvador *et al.*, 2016). Wolfe and Gertler (2004) state that the mixed method, which is a combination of case studies and statistics, is the most effective method to measure and evaluate the level of clusters.

4.1 Classical regression method

One discrepancy seen in the maritime cluster research is the lack of econometric methods such as regression analysis. On the contrary, regression analysis is used in the general cluster literature. For example, positive effects of employment in the cluster on patents per employee (Porter, 2003) and the level of clustering on the entrepreneurship (Delgado *et al.*, 2010) have been observed in this research. Also, the effects of clustering on income and employment increase and urban-rural inequality have been studied by means of regression methods (Yang, 2015).

In this research, to propose an effective clustering model for the Istanbul maritime sector, a mixed method based on a case study survey and econometrics/statistics is used. Simple linear regression analysis and fuzzy linear regression (FLR) analysis are used as econometric methods in this study. Regression analysis is used to describe the distribution of values of one variable, the response, as a function of other explanatory variables. When the different group scores pond to different levels of a quantitative explanatory variable, the idea can be extended with the simple linear regression model, in which the means fall on a straight line function of the explanatory variable. The simple linear regression model makes it possible to draw inference about any mean response within the range of the explanatory variable. It offers a concise summary of the mean of the response variable as a function of the explanatory variable through two parameters: the slope and the intercept of the line (Ramsey and Shafer, 2002). In this study, clustering level is the explanatory variable and firm performance is the dependent variable. Standard equation of simple linear regressions is below:

$$Y = \beta_0 + \beta_1 X_i + \varepsilon_i \tag{1}$$

where Y: dependent variable, X_i: explanatory variable, β_0 and β_1: intercept and slope of the regression line and ε_i: random error.

4.2 Fuzzy linear regression method

Classic regression is problematic if the data set is too small, or there is difficulty verifying that the error is normally distributed, or if there is vagueness in the relationship between the independent and dependent variables, or if there is ambiguity associated with the event or if the linearity assumption is inappropriate. These are the very situations fuzzy regression was meant to address (Shapiro, 2004). As both dependent and independent variable are subjective description (they are based on professionals' evaluations by using a five-point Likert-type scale) in our study, we used FLR, which was first introduced by Tanaka *et al.* in 1982. They used linear programming to determine the regression coefficients as fuzzy numbers. FLR aims to model vague and imprecise phenomena using the fuzzy functions defined by Zadeh's extension principle (Zadeh, 1975), which provides a general method for extending non-fuzzy mathematical concepts to deal with fuzzy quantities (Kim *et al.*, 1996). As the regression coefficients are fuzzy numbers, the estimated dependent variable $\widetilde{Y}$ is also a fuzzy number (Chang and Ayyub, 2001). Fuzzy model takes the form (Wang and Tsaur, 2000):

$$\widetilde{Y} = \widetilde{A}_0 X_0 + \widetilde{A}_1 X_1 + \ldots + \widetilde{A}_N X_N = \widetilde{A}X, \tag{2}$$

where $X = [X_0, X_1, \ldots, X_N]^T$ is a vector of independent variables; $\widetilde{A} = \left[\widetilde{A}_0, \widetilde{A}_1, \ldots, \widetilde{A}_N\right]^T$ is a vector of fuzzy coefficients presented in the form of symmetric triangular fuzzy numbers (TFN) denoted by $\widetilde{A}_j = (\alpha_j, C_j)$ with its membership function (MF) described as below:

$$u_{\widetilde{A}}(a_j) = \begin{cases} 1 - \dfrac{|\alpha_j - a_j|}{c_j}, & \alpha_j - c_j \le a_j \le \alpha_j + c_j, \forall j = 1, 2, \ldots, N, \\ 0, & otherwise. \end{cases} \tag{3}$$

where α_j: central value and C_j: spread value. The equation (2) can be rewritten as:

$$\widetilde{Y}_i = (\alpha_0, c_0) + (\alpha_1, c_1)X_1 + (\alpha_2, c_2)X_2 + \ldots + (\alpha_N, c_N)X_N \tag{4}$$

To find fuzzy coefficients, the following linear programming problem should be solved (Tanaka *et al.*, 1982).

$$\min_{\alpha,c} J = c_1 + \ldots + c_n$$

subject to $c \geq 0$ and

$$\alpha^t x_i + (1-H)\sum_j c_j |x_{ij}| \geq y_i + (1-H)e_i$$

$$-\alpha^t x_i + (1-H)\sum_j c_j |x_{ij}| \geq -y_i + (1-H)e_i$$

$$i = 1, \ \ldots, N. \tag{5}$$

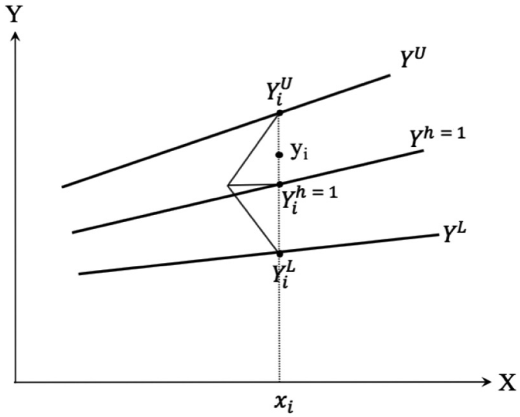
For any given data pair, (x_i, y_i), the foregoing conceptualisations can be summarised by the fuzzy regression interval $[Y_i^L, \ Y_i^U]$ shown in Figure 2 (Shapiro, 2004).

$$Y^{h=1} = \frac{Y_i^U - Y_i^L}{2} \tag{6}$$

$$e_i = \frac{Y_{i(upper)} - Y_{i(lower)}}{2} \tag{7}$$

4.3 The questionnaire and the research sample

The primary data required for this study are collected by means of "The Clustering Level of Istanbul Maritime Sector Survey" which took place between 20 February and 10 June 2017. The survey criteria were based on Porter's diamond model and research of Benito *et al.* (2003), De Langen (2002), Doloreux (2008) and Pinto *et al.* (2015) are used while creating the questionnaire. Cronbach's alpha score of the questionnaire is 0.83, which shows that internal consistency is high. A sample of 200 firms was chosen randomly among the



Source: Shapiro (2004)

Figure 2.
Fuzzy regression interval

maritime firms in Istanbul. The contact details of the firms were given by the Chamber of Shipping in Istanbul. These firms were invited to fill in the survey forms by e-mail, and the entire survey was conducted on-line by means of the Istanbul Technical University VETI (data collecting system) System. In total, 112 forms were completed. Those forms filled in only partially were not evaluated.

4.4 Entropy method

To properly analyse the data sets of the survey results, a definition of the weight of each criterion is vital. In multi decision-making problems, these criteria have different weights and can be easily weighted according to their importance levels. As the entire decision matrix data are known, in this study, an entropy method is used as a tool for criteria evaluation. In this method, the decision matrix for a set of alternatives contains a certain amount of information. A criterion does not function particularly effectively when all the alternatives have similar outcomes for that criterion. Further, if all the values are the same, we can eliminate the criterion (Hwang and Yoon, 1981). The greater the value of the entropy, the smaller the entropy weight, then the smaller the different alternatives in this specific attribute, and the less information the specific attribute provides and the less important this attribute becomes in the decision-making process. This is an objective method in weighting calculations. It is based on the Shannon's (1948) entropy concept as a measurement of uncertainty. The steps of the entropy method are as follows (Wang and Lee, 2009):

4.4.1 Step 1: Normalisation of decision matrix.

$$p_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \quad i = 1, 2, 3, \ldots, m \tag{8}$$

where P_{ij} is normalised values, x_{ij} denotes given values (results from the survey) and i: alternatives and j: criteria.

4.4.2 Calculation of entropy value of each criterion.

$$e_j = \frac{-1}{\ln m} \sum_{i=1}^{m} p_{ij} \,.\, \ln p_{ij} \quad j = 1, 2, 3, \ldots, n \tag{9}$$

where e_j: entropy value and P_{ij}: normalised values.

4.4.3 Calculation of weight of each criterion.

$$w_j = \frac{1 - e_j}{\sum_{j=1}^{n} (1 - e_j)} \quad j = 1, 2, 3, \ldots, n \tag{10}$$

where w_j: weight values and e_j: entropy values.

It can be easily understood that the sum of all weight values are 1.

$$\sum_{j=1}^{n} \mathrm{w_j} = 1 \tag{11}$$

In the study, 45 criteria for the clustering level variable and 3 criteria for the firm performance variable were defined. Then, the criteria were weighted by using the entropy method and the relationship between clustering and firm performance was measured by means of simple linear regression and FLR methods.

5. Findings of the study

In our study, we asked the following research questions: "What is the clustering level of Istanbul's maritime sector?", "How can we propose an appropriate model of clustering for Istanbul's maritime sector?" and "Is there a positive correlation between clustering level and firm performance?". By means of our survey, we have tried to find answers to these questions.

Distribution of 112 maritime firms to the sub-sectors is almost balanced. This provides us with a means of comparison for the sub-sectors. The percentage of the respondents which has executive roles in the firms (owner/co-owner and high level managers) is high (73 per cent). These executives have great experience in maritime sector. So it can be assumed that the answers reflect the true nature of the surveyed firms and the sector. Also, educational levels of respondents are high (percentage of undergraduate and master's/PhD degrees is 88 per cent). This strengthens the scientific findings of the survey (Table I).

5.1 Factor conditions

It is not surprising that Istanbul, which is the most-developed city of Turkey in terms of social and economic aspects, has above average factor condition scores. Istanbul is attracting the younger generation due to its many advantages, so the high-quality workforce of Turkey tends to be educated and employed in Istanbul. According to the survey results, the status of substructure is above average (3.36) but comparing with the high levels of other factors, it is not satisfactory, and there is still a long way to go. The highest score is the reachability to suppliers (4.27), but the quality of suppliers is not particularly high (3.76). The score of opportunities to reach financial institutions is above average (3.49), but it is far behind expectations because Istanbul has a goal to become a financial centre in its region and in the globe. It has been seen that the Ship/Yacht Building and Maritime Equipment sub-sectors are more pleasant in terms of sub-structure (3.76) and reachability to financial institutions (3.83) compared with other sub-sectors. The reachability to R&D is the lowest but slightly above the average (3.13). As a summary of all factor condition questions, the answers to the question of "What is the level of positive effect of your location choice on your business performance?" show that Istanbul is far above the average (4.12) and has a very promising level for factor conditions (Table II).

5.2 Demand conditions

When we evaluate demand conditions of Istanbul's maritime sector, we can easily find that customer demand for high-quality goods and services is high (4.42). Also, the demand structure is forcing firms to innovate, and this shows us the need for an innovative maritime sector (3.34). There is a demand variety in the Istanbul maritime sector (3.74), but the low level of foreign demand (2.60) is a limiting factor against the global competitiveness of the sector (Table III).

Characteristics of respondents	Frequency	(%)
Sub-sector		
Maritime rransportation	40	35.71
Supporting firms for the maritime transportation	42	37.5
Ship/yacht building and maritime equipment	30	26.78
Job title		
Owner/Co-owner	53	47.32
High level manager	29	25.89
Mid-level manager	20	17.85
Employee	10	8.92
Total experience in maritime sector		
Less than 10 years	25	22.32
11-20 years	30	26.78
21-30 years	30	26.78
Over 30 years	27	24.1
Length of service in company		
Less than 10 years	59	52.67
11-20 years	28	25
21-30 years	20	17.85
Over 30 years	5	4.46
Educational background		
High school	11	9.82
Undergraduate	70	62.5
Master's degree	29	25.89
PhD	2	1.78

Table I. Profile of respondents

Criteria	Maritime transportation	Supporting firms for the maritime transportation	Ship/yacht building and maritime equipment	All sub-sectors
1. Reachability to high-quality workforce	3.61	3.65	3.83	3.69
2. Quality of sub-structure	3.26	3.06	3.76	3.36
3. Reachability to financial institutions	3.35	3.30	3.83	3.49
4. Reachability to R&D	3.00	3.06	3.33	3.13
5. Reachability to suppliers	4.17	4.23	4.43	4.27
6. Quality of suppliers	3.67	3.76	3.86	3.76
7. What is the level of positive effect of your location choise on your business performance?	4.03	3.94	4.40	4.12

Table II. Survey results for factor conditions (n = 112) (1 = lowest, 5 = highest)

5.3 Firm strategy and rivalry

In Istanbul's maritime sector, the level of national and international competition is high (3.65 and 3.68) and the number of internal and external rivals is significant (4.09 and 4.17). Entrance barriers to the internal and external markets are also high (3.71 and 3.97). These competition levels are significant factors which enforce the firms to cluster. The competing firms are cooperating at the same time in R&D (2.66), standardisation (3.09), lobbying (2.79), marketing (2.58) and procurement (2.51) at just below average frequencies. To achieve the goal of having a globally competitive Istanbul maritime sector, this cooperation level should be increased. When we analyse the answers to the questions which provides us the level of innovation of the firms, it can be seen that these firms (mostly the Ship/Yacht Building and Maritime Equipment firms) are giving importance to innovation and its education (2.97 and 3.69). On the other hand, R&D costs/Turnover (2.7) and Innovation investments/Total investments (1.76) ratios are lower than the average. Generally, the sector is aware of the importance of innovation, but it is impossible to define maritime firms as innovative. Finally, when we analyse answers to the questions which measure the firms' approaches to the necessity of clustering, it can easily be seen that most of the firms have a very positive vision for clustering.

5.4 Related and supporting industries

In Istanbul's maritime sector, the levels of relationship and cooperation of the firms with their customers (4.34) and suppliers (4.05) are high; with financial institutions (3.33), their rivals (3.15), business associations and chamber of commerce (3.05) and experts (consulting firms, engineering firms, etc.) (3.02) are average; and with universities (2.11) and R&D institutions (1.96) are low. In this aspect, there is a meaningful relationship and cooperation among the stakeholders in the sector but one cannot adequately provide details regarding the established and developed maritime cluster. Successful clusters only can be achieved by good relationship and cooperation between firms and their rivals, universities and R&D institutions. The level of relationship and cooperation is higher in the Ship/Yacht Building and Maritime Equipment sub-sector than the others. It is evaluated that this situation stems from the facts that; this sub-sector is well organised and clustered, the locations of the firms are close to each other, enabling an effective cluster (all of the shipyards in Istanbul are located in the Tuzla area), firms are cooperating in procurement of common raw material and equipment, and also they are giving joint proposals as consortiums to the large shipbuilding projects. Finally, cooperation for innovation level is just above average (3.27) in this sub-sector, and below average in the others (2.75 and 2.62) (Tables IV and V).

5.5 Criteria for firm performance

Three questions were asked to measure firm performance. Sustainability was measured with firm age, contribution to employment was measured with the increase of the number of employees and finally contribution to economic growth was measured with turnover growth. All three answers of the sub-sectors are close to average.

Table III.
Survey results for demand conditions ($n = 112$) (1 = lowest, 5 = highest)

Criteria	Maritime transportation	Supporting firms for the maritime transportation	Ship/yacht building and maritime equipment	All sub-sectors
8. Customer demand for quality	4.39	4.37	4.50	4.42
9. Customers forcing the sector for innovation	3.40	3.47	3.17	3.34
10. Demand variety	3.73	3.92	3.58	3.74
11. Proportion of foreign demand	2.84	2.65	2.33	2.60

Criteria	Maritime transportation	Supporting firms for the maritime transportation	Ship/yacht building and maritime equipment	All sub-sectors
12. National competition level	3.62	3.80	3.53	3.65
13. International competition level	3.76	3.92	3.36	3.68
14. Cooperation in R&D while competing	2.72	2.87	2.41	2.66
15. Cooperation in standardisation while competing	3.10	3.28	2.89	3.09
16. Cooperation in lobbying while competing	2.77	2.90	2.70	2.79
17. Cooperation in marketing while competing	2.82	2.44	2.50	2.58
18. Cooperation in procurement while competing	2.62	2.45	2.46	2.51
19. Number of the rivals in internal markets	4.49	4.45	3.33	4.09
20. Number of the rivals in international markets	4.30	4.43	3.79	4.17
21. Number of the cooperative firms in your sub-sector	3.40	3.30	3.50	3.40
22. Entrance barriers to internal markets	3.64	3.97	3.53	3.71
23. Entrance barriers to international markets	3.95	3.90	4.06	3.97
24. Are you making innovations in your firm?	2.50	2.99	3.43	2.97
25. Are you educating your personnel in innovation?	3.55	3.54	4.00	3.69
26. Level of technological innovation of your firm	3.12	3.42	3.45	3.33
27. Level of organisational innovation of your firm	2.83	3.20	3.25	3.09
28. Variety of keeping up with the sectoral innovations	2.27	2.07	2.65	2.33
29. R&D costs/Turnover	2.25	2.79	3.08	2.70
30. Innovation investments/Total investments	1.56	1.81	1.93	1.76
31. Rivalry between firms in your sector/sub-sector enforce them to innovate and in the long run this strengthens their competitiveness and effectiveness	3.64	3.40	4.33	3.79
32. Cooperation in certain issues between firms in your sector/sub-sector increase their effectiveness and strengthens the sector/sub-sector as a whole	3.63	3.53	3.50	3.55
33. The presence of “Common Action Plans” which enforce the cooperation of the stakeholders strengthens the sector/sub-sector in a way that everyone can benefit from	3.56	3.61	3.53	3.56
34. Great number of the leader firms strengthens the sector/sub-sector as a whole	3.53	3.37	3.76	3.55

Table IV.
Survey results for firm strategy and rivalry (n = 112) (1 = lowest, 5 = highest)

5.6 Istanbul maritime cluster mapping

It was asked from the participants of the survey to write down the top three sub-sectors which they related to. Figure 3 explains those relationships in a Web form. The most intense relationships are between maritime transportation and their suppliers, between shipyards

Criteria	Maritime transportation	Supporting firms for the maritime transportation	Ship/yacht building and maritime equipment	All sub-sectors
35. Level of relationship and cooperation with your customers	4.27	4.37	4.40	4.34
36. Level of relationship and cooperation with your suppliers and subcontracters	3.97	3.97	4.23	4.05
37. Level of relationship and cooperation with your rivals	2.91	2.65	3.90	3.15
38. Level of relationship and cooperation with universities	1.99	2.08	2.26	2.11
39. Level of relationship and cooperation with R&D institutions	1.90	1.88	2.10	1.96
40. Level of relationship and cooperation with business associations and chamber of shipping	3.00	2.92	3.23	3.05
41. Level of relationship and cooperation with experts (consulting firms, engineering firms, etc.)	3.01	2.83	3.23	3.02
42. Level of relationship and cooperation with financial institutions (banks, insurance, leasing/factoring, stock brokers, etc.)	3.35	3.21	3.43	3.33
43. Variety of relationship and cooperation	2.10	1.95	2.41	2.18
44. Data and experience sharing between related and supporting industries strengthens sector/sub-sector as a whole	3.84	3.85	4.06	3.91
45. Do you participate to the cooperation activities of innovation through your sector/sub-sector?	2.75	2.62	3.27	2.88

Table V. Survey results for related and supporting industries ($n = 112$) (1 = lowest, 5 = highest)

and marine equipment manufacturers and between maritime transportation firms and shipyards. Maritime transportation is at the centre of the Web due to its strong relationships with the most of the sectoral stakeholders. This fact requires that maritime transportation should be at the centre of the Istanbul Maritime Cluster Map. Figure 4 is a map proposal for the Istanbul Maritime Cluster.

5.7 Entropy calculations

Tables VII to XII

5.8 Regression analysis of the survey results

5.8.1 Simple linear regression analysis. Descriptive statistics show that the variables are normally distributed which enables parametric tests (Figure 5 and 6) (Table XIII).

We conducted a simple linear regression analysis of the variables using the EViews 9 statistics program.

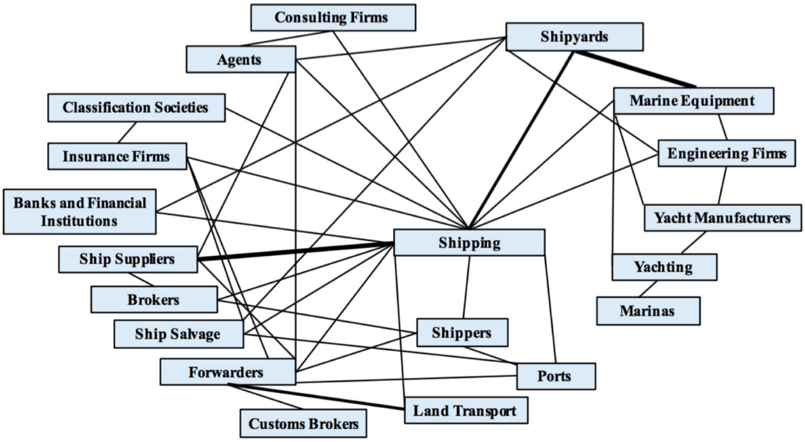


Figure 3. Istanbul maritime sector web of relationships

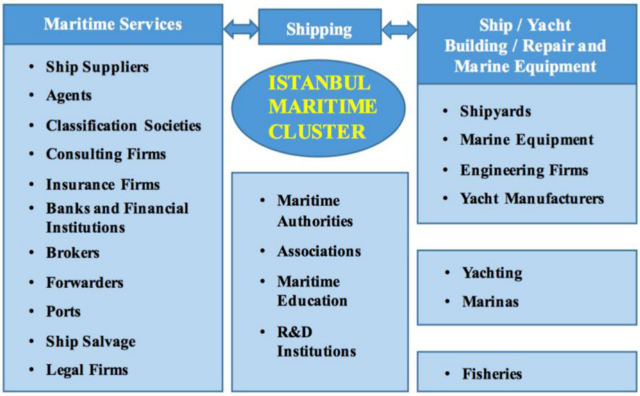


Figure 4. Istanbul maritime cluster map

Criteria	Maritime transportation	Supporting firms for the maritime transportation	Ship/yacht building and maritime equipment	All sub-sectors
1. Age of your firm	2.65	2.76	2.83	2.74
2. Change in the employment in your firm	2.90	2.71	2.80	2.80
3. Change in the turnover in your firm	2.70	2.92	2.83	2.81

Table VI. Survey results for firm performance (n = 112) (1 = lowest, 5 = highest)

Table VII.
Decision matrix for clustering level variable

	Criteria (j)								
	1	2	3	4	5	6	7	...	45
Alternatives (i)									
1	4	3	3	3	4	4	4		5
2	4	4	3	3	4	4	4		5
3	2	2	1	2	4	4	3		1
4	4	2	2	1	4	4	5		1
5	5	4	4	4	5	4	5		5
6	4	4	4	4	4	4	4		5
7	4	3	2	1	4	4	4		5
8	4	2	2	2	3	3	4		5
9	4	2	4	4	4	4	4		5
10	3	3	3	3	4	3	4		1
...									
112	4	3	4	4	3	3	4		5
$\sum_{i=1}^{m} x_{ij}$	405	365	376	338	466	411	450		320

Table VIII.
Decision matrix for firm performance variable

	Criteria (j)		
	1	2	3
Alternatives (i)			
1	1.25	3	4
2	1.25	2	2
3	2.5	1	1
4	3.75	1	2
5	2.5	2	2
6	2.5	3	3
7	3.75	4	4
8	3.75	1	1
9	3.75	1	1
10	2.5	4	3
...			
112	1.25	4	4
$\sum_{i=1}^{m} x_{ij}$	307.5	314	316

$$(\text{Firm performance}) = 1.264985 + 0.507191(\text{Clustering level}) \tag{12}$$

The *p*-value (0.000375) for the F test statistic was less than 0.01, indicating strong evidence of alternative hypothesis against the null hypothesis. The squared multiple correlation (R^2 = 0.1091) indicates that approximately 11 per cent of the variability in the firm performance variable is explained by the clustering level variable. Thus, the remaining 89 per cent of the firm performance can be explained by other variables. Although results from our model were found to be statistically significant, the explanation ratio of independent variable (clustering level) for dependent variable (firm performance) is not high. Therefore, there is a limited positive effect of clustering level on the firm performance in this case. This result could be stemmed from the fact that the criteria in the questionnaire were evaluated by the sector professionals in parallel with their subjective thoughts about the cluster concept. Also, the number of the criteria for the independent variable was quite high, but dependent variable had only three criteria, which probably caused some measurement errors. For

	Criteria (j)								
	1	2	3	4	5	6	7	...	45
Alternatives (i)									
1	0.00987	0.00821	0.00797	0.00887	0.00858	0.00973	0.00888		0.01562
2	0.00987	0.01095	0.00797	0.00887	0.00858	0.00973	0.00888		0.01562
3	0.00493	0.00547	0.00265	0.00591	0.00858	0.00973	0.00666		0.00312
4	0.00987	0.00547	0.00531	0.00295	0.00858	0.00973	0.01111		0.00312
5	0.01234	0.01095	0.01063	0.01183	0.01072	0.00973	0.01111		0.01562
6	0.00987	0.01095	0.01063	0.01183	0.00858	0.00973	0.00888		0.01562
7	0.00987	0.00821	0.00531	0.00295	0.00858	0.00973	0.00888		0.01562
8	0.00987	0.00547	0.00531	0.00591	0.00643	0.00729	0.00888		0.01562
9	0.00987	0.00547	0.01063	0.01183	0.00858	0.00973	0.00888		0.01562
10	0.0074	0.00821	0.00797	0.00887	0.00858	0.00729	0.00888		0.00312
...									
112	0.00987	0.00821	0.01063	0.01183	0.00643	0.00729	0.00888		0.01562

Table IX. Normalised decision matrix for clustering level variable

	Criteria (j)		
	1	2	3
Alternatives (i)			
1	0.01626	0.00955	0.01265
2	0.00406	0.00955	0.00949
3	0.00406	0.00636	0.00632
4	0.00406	0.00955	0.01265
5	0.01626	0.00955	0.01265
6	0.00813	0.00636	0.00632
7	0.01219	0.00318	0.00949
8	0.00406	0.01273	0.01265
9	0.00406	0.01273	0.00632
10	0.01219	0.00636	0.00632
...			
112	0.00813	0.01273	0.01265

Table X. Normalized decision matrix for firm performance variable

future research, to obtain detailed financial facts from the maritime firms about their performance is strongly recommended.

5.8.2 Fuzzy linear regression analysis. As both dependent and independent variable are subjective description, and there is vagueness in the relationship between them, we conducted an FLR analysis (Table XIV and XV).
By means of these data, we fit straight lines through two or more heuristically determined data points in such a way that they bound the data points from above and below. $Y_U = 0.73x + 2.09$ and $Y_L = 0.93x - 1.63$. The mean of these lines is $Y^{h=1} = 0.83x + 0.23$ (Figure 7).

Central values (α_j) were found by means of standard regression analysis between x values (clustering level) and the $Y^{h=1}$ values. Spread values (c_j) were found by means of standard regression analysis between x values (clustering level) and the e_i values. H-value can be selected between 0 and 1. It was selected as 0.5 by the researchers. Finally, the FLR equation for H = 0.5 was formed as below:

$$(\text{Firm performance}(\widetilde{Y})) = (0.23, 0.93) + (0.83, 0.05)(\text{Clustering level}) \quad (13)$$

a. Clustering level									
1	2	3	4	5	6	7	8	9	10
0.98982	0.98573	0.98531	0.96652	0.99485	0.99094	0.99347	0.99582	0.98984	0.98602
11	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*
0.98211	0.9981	0.98755	0.9775	0.97771	0.97815	0.9773	0.97854	0.98929	0.98905
21	*22*	*23*	*24*	*25*	*26*	*27*	*28*	*29*	*30*
0.9831	0.99022	0.99144	0.98115	0.96554	0.98307	0.98646	0.985	0.9766	0.97714
31	*32*	*33*	*34*	*35*	*36*	*37*	*38*	*39*	*40*
0.99198	0.99199	0.99278	0.98956	0.99636	0.99204	0.99026	0.9767	0.97622	0.97922
41	*42*	*43*	*44*	*45*					
0.98788	0.98852	0.98612	0.99518	0.9467					

b. Firm performance		
1	*2*	*3*
0.9821	0.9823	0.98488

Table XI.
Entropy values of the criteria

a. Clustering level									
1	2	3	4	5	6	7	8	9	10
0.01485	0.02082	0.02144	0.04886	0.00751	0.01322	0.00953	0.0061	0.01482	0.0204
11	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*
0.02611	0.00277	0.01817	0.03283	0.03253	0.03189	0.03313	0.03132	0.01563	0.01598
21	*22*	*23*	*24*	*25*	*26*	*27*	*28*	*29*	*30*
0.02466	0.01427	0.01249	0.02751	0.05029	0.0247	0.01976	0.02189	0.03415	0.03336
31	*32*	*33*	*34*	*35*	*36*	*37*	*38*	*39*	*40*
0.0117	0.01169	0.01053	0.01523	0.00531	0.01161	0.01421	0.034	0.0347	0.03032
41	*42*	*43*	*44*	*45*					
0.01768	0.01675	0.02025	0.00703	0.07779					

b. Firm performance		
1	*2*	*3*
0.35291	0.34897	0.2981

Table XII.
Weights of the criteria

6. Conclusions

Clustering is a national, regional or local cooperation and development model of interrelated firms and supplementary institutions in a particular sector to gain global competition advantage. Countries use maritime clusters as a tool to increase their global competition power in the maritime sector. They generally locate their maritime transportation sub-sector in the heart of the cluster organisation and supporting firms for the maritime transportation and ship/yacht building and maritime equipment sub-sectors on the periphery. It is imperative for Turkey to develop its maritime capacity in the near future. Due to the fact that 90 per cent of international trade is carried out via seaways, Turkey has no other option than to invest in its maritime sector.

That being said, the clusters should be analysed by using quantitative methods to comprehend the level of clustering in any region or city. In this context, by conducting a survey and analysing the results with statistical methods, the level of Istanbul's maritime cluster has been measured in this article. Istanbul, as a city, provides a very suitable environment for its maritime sector to cluster. However, it is impossible to say that there is an established and developed maritime cluster at present. Istanbul's maritime cluster is about to prosper. According to the Zhang and Lam's classification, it is evaluated that the

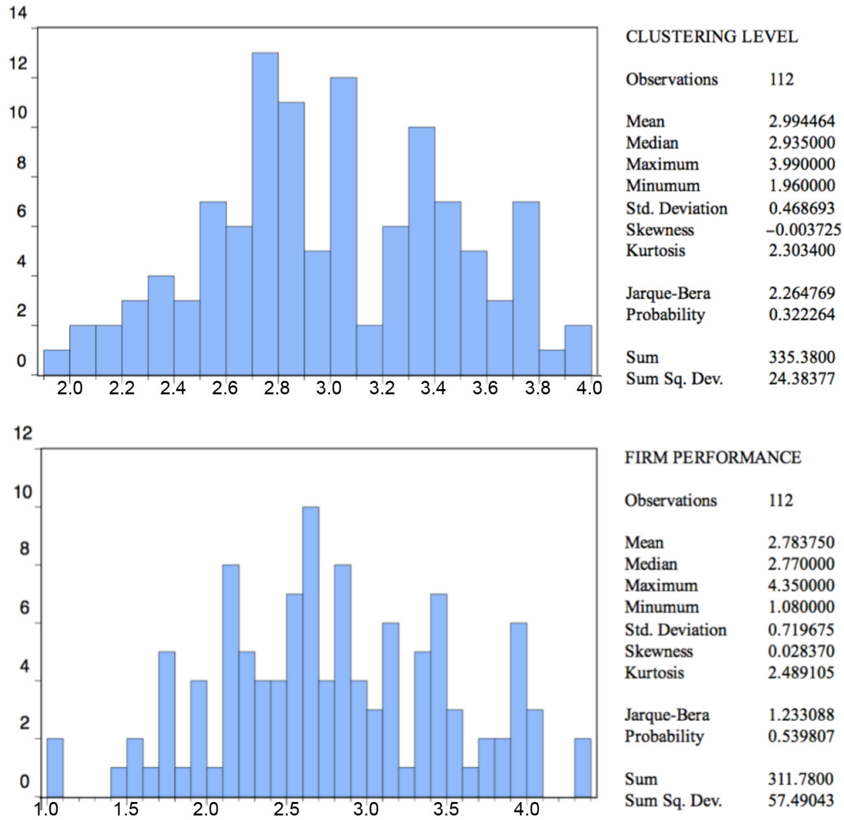


Figure 5.
Descriptive statistics of the variables

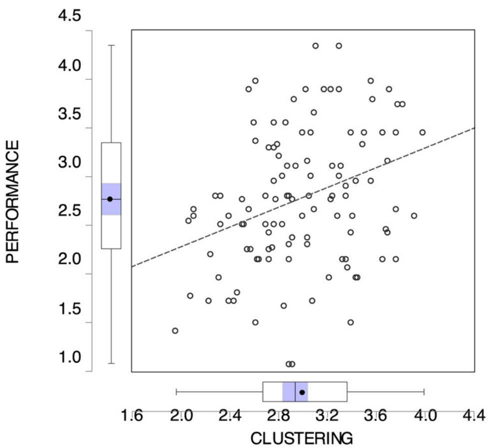


Figure 6.
Scatter plot, box plot and simple linear regression line showing the relationship between clustering level and firm performance

Istanbul maritime sector is partly at the third stage, which means that it is a regional supply chain hub in economic and trade markets. Becoming a global player at the third stage and also transitioning to the fourth stage requires a strong maritime cluster.

One of the major deficits of Istanbul's maritime cluster is the very low level of cooperation among maritime firms. The maritime firms in particular tend not to cooperate with their rivals in the cluster. Successful clusters can only be achieved by good relationships and cooperation between rivals in the cluster. Also firms' low level of relationship and cooperation with related institutions such as universities and R&D institutions weakens the innovative potential of Istanbul's maritime cluster.

Table XIII. Output of the simple linear regression analysis of the relationship between clustering level and the firm performance

Variable	Coefficient	Std. error	t-Statistic	Prob.
C	1.264985	0.418786	3.020598	0.0031
Clusterıng	0.507191	0.138186	3.670349	0.0004
R-squared	0.109106	Mean dependent var		2.783750
Adjusted *R*-squared	0.101007	S.D. dependent var		0.719675
S.E. of regression	0.682361	Akaike info criterion		2.091181
Sum squared resid	51.21788	Schwarz criterion		2.139726
Log likelihood	−115.1061	Hannan-Quinn criter.		2.110877
F-statistic	13.47146	Durbin-Watson stat		2.366884
Prob (*F*-statistic)	0.000375			

Notes: Dependent Variable: PERFORMANCE; Method: Least Squares; Date: 12/01/17 Time: 04:38; Sample: 1 112; Included observation: 112

Table XIV. Data pairs

i	1	2	3	4	5	6	7	8	9	10	...	112
x_i	3.56	2.91	2.39	2.1	3.56	3.33	2.06	3.3	3.7	2.4		3.99
y_i	4	2.38	1.73	2.68	4	2.17	2.56	3.02	2.43	2.61		3.47

Table XV. Comparison of the simple linear regression and the FLR results

i	Real value (Y)	Simple linear regression (Y)	FLR Lower limit	Upper limit	Mean	Limits for H = 0.5 Lower limit	Upper limit
1	4	3.07058496	1.6808	4.6888	3.1848	2.43	3.93
2	2.38	2.74091081	1.0763	4.2143	2.6453	1.855	3.425
3	1.73	2.47717149	0.5927	3.8347	2.2137	1.4	3.02
4	2.68	2.3300861	0.323	3.623	1.973	1.145	2.795
5	4	3.07058496	1.6808	4.6888	3.1848	2.43	3.93
6	2.17	2.95393103	1.4669	4.5209	2.9939	2.225	3.755
7	2.56	2.30979846	0.2858	3.5938	1.9398	1.1	2.76
8	3.02	2.9387153	1.439	4.499	2.969	2.195	3.725
9	2.43	3.1415917	1.811	4.791	3.301	2.555	4.045
10	2.61	2.4822434	0.602	3.842	2.222	1.41	3.03
...							
112	3.47	3.28867709	2.0807	5.0027	3.5417	2.81	4.27

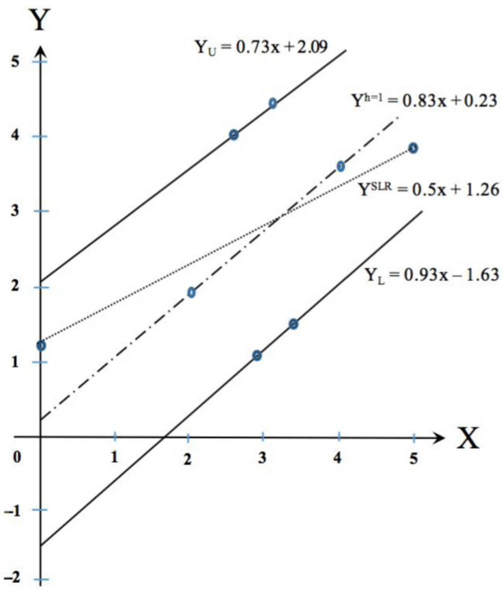


Figure 7.
Fuzzy regression interval

A lack of a coordination authority which has some coordination responsibilities among the maritime cluster is another major hindrance for Istanbul to become a better maritime cluster in the near future.

The number of leader firms in Istanbul's maritime cluster is insufficient to gain a global competitive strength in the maritime sector. For the development of the Istanbul maritime cluster in the near and middle term, the presence of leader firms which have the ability to create synergy through the maritime sector is a vital need. In the meantime, the government should take most of the responsibility to enhance the maritime cluster using a topside-down approach. Most firms participating in the survey stated that government support for the maritime sector should be increased. On the contrary, most of the firms prefer a bottom-up approach which gives them much more power in decision-making processes. It is such a contradiction for them, so a combination of two different approaches would be a solution. This issue is vital because to propose an appropriate model of clustering for Istanbul's maritime sector, policy makers and the sector professionals should decide which approach is more suitable and useful for the cluster.

Another dimension of the clustering model proposal is the definition of the core sub-sector. Maritime transportation is at the centre of the cluster web due to its strong relationships with the most of the sectoral stakeholders. As a model proposal, Istanbul Maritime Cluster Map is formed by this research.

From the survey, it can be easily understood that maritime firms are evaluating the cluster concept in a positive way. Even some professionals who had not heard about this concept previously, stated that they would participate in such an organisation. This implies that we can look into the future more hopefully in this area.

In this study, the effect of clustering level on firm performance was evaluated by means of simple linear regression and FLR methods. As a result of simple linear regression, the relationship of the variables in our model is statistically significant, but the effect of clustering level on firm performance is not high. We evaluate that this situation stemmed from the fact that both dependent and independent variable were subjective description and also the number of the criteria for the firm performance variable were inadequate to measure its actual level precisely. So we used a FLR method to analyse that relationship.

For further research, input/output analysis should be carried out to illustrate the Istanbul maritime cluster's economic linkages. However, this requires a significant amount of statistical data based on firms' financial activities. This method is imperative for understanding the true nature of interconnections among the cluster participants.

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