The Ninth International Conference on Construction in the 21st Century (CITC-9)
"Revolutionizing the Architecture, Engineering and Construction Industry through Leadership, Collaboration and Technology" March 5th-7th, 2017, Dubai, United Arab Emirates

Algorithm for the determination of abnormally low tenders in public construction contract bids in Greece

Antonios Panas
(Ph.D., Centre for Construction Innovation, National Technical University of Athens, Athens, Greece)

John-Paris Pantouvakis
(Professor, Centre for Construction Innovation, National Technical University of Athens, Athens, Greece & Visiting Professor, Department of Civil Engineering, Nazarbayev Unversity, Astana, Kazakshtan)

Alexandros Romosios
(M.Sc., ERETBO S.A., Athens, Greece)

Efstratios Zissimopoulos
(M.B.A., Ziss Constructions S.A., Athens, Greece)

Abstract
The detection of abnormally low tenders for the tendering of public construction projects is a long-standing issue in the industry. However, the economic crisis and the ever increasing competition amongst the construction companies, has led to an intensification of that issue, especially in competitive tendering schemes, where the project is awarded to the lowest bidder. The aim of the current study is to determine an easy-to-implement algorithm that would objectively detect abnormally low tenders, taking into account the characteristics of the Greek construction industry. The application of the proposed method in 46 public projects which were tendered in the last two years in Greece showed that the lowest bidder would ultimately submit a discount rate 5-10% lower than the initial. A very important issue is the objective determination of the form of explanations that the abnormally low bidders should provide according to the European legislation (2014/24/EU).

Keywords
Abnormally low tenders, Bidding, Public projects, Tender.

1. Introduction

The ability to detect the abnormally low tenders in public construction contracts guarantees transparency, publicity and equal opportunity in the procurement process (Ballesteros-Perez *et al.*, 2015b). In Greece, the most commonly used public procurement method is the one where the contract is awarded to the lowest bidder. Despite its widespread use, the traditional lowest bid method is considered by many to be a recipe for trouble, since it leads to unusually high discount rates in the submitted offers (Oviedo-Haito *et al.*, 2014). As a result, the tendering authorities have to address numerous claims on behalf of the participating companies, while the time schedule and the quality standards are often affected to the detriment of the project itself. Therefore, it is crucial to identify the financial boundary which represents the break-even point of the project cost from the tendering authority's standpoint. In other words, this boundary would express the highest acceptable discount rate (or, equivalently, the lowest acceptable

offer), beyond which there is no substantial justification that the project would be profitable for the contractor who is awarded the project. Within the scope of this study, this financial boundary is called the "Project Cost Limit" (PCL).

This paper aims at objectively specifying the PCL through the implementation of an algorithmic process that takes into account the quoted tender prices. First, background information on pertinent research regarding the abnormally low bids criteria in construction tenders is provided coupled with a concise description of the research methodology. Then, a case study is presented, which includes the application of the presented methodology in 46 public projects that were tendered in Greece during the period 2014-2016. Finally, the main emerging inferences and proposals for further research will conclude the study.

2. Abnormally low tenders

2.1. The Greek status-quo

Until recently, the Greek construction industry was governed by a law which was introduced in 2008 (Law 3669/2008) and described different contract awarding methods (e.g. lump sum, unit-price, BOT). In practice though, the unit-price-model was widely adopted by public authorities, because it seemed to guarantee transparency in the awarding process. However, the increased competition amongst construction companies led to the submission of extremely low offers, where the discount rate from the project budget would reach 60%-65% for projects with an estimated break-even point at approximately 25%. Thus, the submission of abnormally low tenders (ALTs) (i.e. with an abnormally high discount rate) affected negatively both the awarding process, as well as the construction phase of the project itself (Wang *et al.*, 2006). Therefore, a strong discussion was initiated within the industry partners, in order to classify bids as abnormal and combat collusion, as those bidders who manage to form a viable cartel or bidding ring can seriously affect winning bid values (Hu *et al.*, 2011). The main inference from the discussion was that the problem of ALTs is very severe, but public authorities seem to lack the proper tools to fight it.

On a European level, the issue of the ALTs has been highlighted in a seminal report of the European Commission titled "Prevention, Detection and Elimination of Abnormally Low Tenders" (European Union, 1999). More specifically, the Directorate General (DG III) working group, which is responsible for economic policy and financial markets in the EU summarized in the aforementioned report the negative effects of ALTs and formulated proposals for action (e.g. awarding the projects to the economically most advantageous tender (EMAT)). This study adopts the definition of ALTs as provided in the report as follows:

A tender is assumed to be abnormally low if: (a) in the light of client's preliminary estimate and of all the tenders submitted, it seems to be abnormally low by not providing a margin for a normal level of profit and (b) in relation to which the tenderer cannot explain his price on the basis of the economy of the construction method, or the technical solution chosen, or the exceptionally favourable conditions available to the tenderer, or the originality of the work proposed.

The European Union built upon the results of that report and referred specifically to the issue of ALTs in Article 55 of directive 18/2004/EC (European Union, 2004), which was later replaced by Article 69 of directive 24/2014/EC (European Union, 2014). The latter has been adopted to the Greek construction industry in the Article 88 of Law 4412/2016 published on 8th August 2016. The new directive (and the respective Greek law) highlight explicitly that tenderers should justify their offers by elaborating on the selected construction methods, technical solutions, innovative characteristics of the construction process and the exceptionally favourable conditions that would increase their productivity. However, no specific evidence is provided as to which qualitative and/or quantitative method should be used to detect an ALT.

In fact, Law 4412/2016 clearly states that this is an open issue which will be addressed in due time. As such, the most common methods used to detect ALTs are summarized in the following paragraph.

2.2. Abnormally Low Tenders detection criteria

There is no consensus in published literature as to what is the most efficient way to characterize an offer as abnormally low (Murat and Volkan, 2008). There are two major groups: qualitative and quantitative approaches. The former is expressed by setting a cut-off discount rate beyond which a bid is considered as ALT. For example, Megremis (2014) presented such a qualitative framework that is depicted in Table 1. Up to a certain deviation, either from the mean of the bids or from the cost estimation, there is ambiguity on whether tenders should be examined (i.e. the investigation is optional and depends on the authority). However, above that point (i.e. more than 35% deviation) tenders should undoubtedly be investigated. On the other hand, Belesteros-Perez (2015a/b) reviewed several existing quantitative systems for the detection of ALT and concluded that despite their differences they all converge to the same principle: arithmetic systems that measure the deviation of a particular bid from the average of all bids submitted, with minor differences in the percentage and/or calculation of the average. In that sense, six generic quantitative methods were identified, as presented in Table 2. The aforementioned methods formed the backbone for the formulation of the research methodology, as will be presented in the next section.

Table 1: Qualitative framework for ALT detection (adopted by Megremis (2014))

Deviation of Tender	Action	Number of bids	Suggested indicator
15-35%	Optional investigation	<5	Cost estimation
15-35% or >35%	Depends on the Authority	5-7	Mean of all bids
>35%	Obligatory investigation	>7	Mean of the bids excluding the highest and the lowest

Table 2: Mathematical formulas for ALT detection (adopted by Belesteros-Perez (2015b))

No.	Formula	Description
1	$b_{abn} = (1-\varepsilon)\, b_m$	Possible in both capped and uncapped tenders and the most common criterion in EU countries. Parameter ε is usually set 0.05-0.20.
2	$d_{abn} = (1+\theta)\, d_m$	Possible in capped tenders only. Parameter θ is usually set 0.05-0.20.
3	$b_{abn} = b_m - \lambda\, s$	Possible in both capped and uncapped tenders (under the expression $d_{abn} = d_m + \lambda\, s$). It sets a threshold in bid or discount standard deviation multiples beyond which all bidders are disqualified. Parameter λ is usually set 0.5-2.0.
4	$N_{abn} = (1-\mu)\, N/2$	Possible for capped and uncapped tenders. Basically, this criterion directly eliminates a proportion μ of bidders just for being located at the extremes (in one or in both extremes lowest and highest). Parameter μ usually ranges between 0.05 and 0.25.
5	$b_{abn} = \omega$	It is a deterministic cut-off limit for a particular economic amount the auctioneer considers too low to be acceptable.
6	$d_{abn} = \delta$	Similar to the previous criterion, but only applicable for capped tenders. This sets a discount value above which any bidder will be disqualified. Parameter δ is generally set within the range 0.10 to 0.30.

where: $\mathbf{b_{abn}}$: cut-off bid; $\mathbf{b_m}$: average bid; $\mathbf{d_{abn}}$: cut-off discount; $\mathbf{d_m}$: average discount; **N**: number of bids submitted; $\mathbf{N_{abn}}$: number of bids set as ALT; **s**: standard deviation; **δ**: set value discount parameter; **ε**: bid parameter; **θ**: discount parameter; **λ**: multiplier parameter; **ω**: set value bid parameter

3. Research Methodology

The research methodology is depicted in Figure 1 below. First, all submitted bids are ranked in descending order based on the submitted discount rates. Then, a statistical normality check is performed for the sample. More specifically, it is assumed that in a bid with no collusion, bid-covering or bid rotation practices, the submitted offers should follow the Normal distribution, as dictated by recently published literature (Ballesteros-Perez and Skitmore, 2016; Skitmore, 2002). The absence of collusion is a prerequisite in order to consider all bids as independent and identically distributed data; otherwise the statistical analysis is not valid. The check is based on three very common and scientifically acceptable statistical criteria: (a) D'Agostino's K-squared, (b) Shapiro-Wilk and and (c) Kolmogorov-Smirnov. The reader is referred to Kutner et al. (2005) for more information on the particulars of each test. These three tests give an adequate goodness-of-fit result which suffices for the scope of the current research. The statistical process is strict, since all three tests must be successful, in order to advance to the next step. If either one of the checks fails, then the extreme bids are excluded from the sample in a sequential fashion: first the highest discount, then the lowest and so on. After each bid exclusion, the statistical checks are repeated up until all three of them yield successful results.

In the next step the method makes an assumption as to where to put the PCL. In more detail, we adopt the third mathematical formula of Table 2 ($b_{abn} = b_m - \lambda s$), where the parameter λ is set equal to 1.0. The setting of one standard deviation as the PCL is not arbitrary, since it is very commonly used as denoted by the research of Ballesteros-Perez et al. (2015b). The last step of the process divides the sample in two groups, namely the acceptable offers and the non-acceptable or Abnormally Low Tenders, which must be further investigated. The proposed algorithm's implementation in real projects tendered in Greece for the period 2014-2016 is presented in the next section.

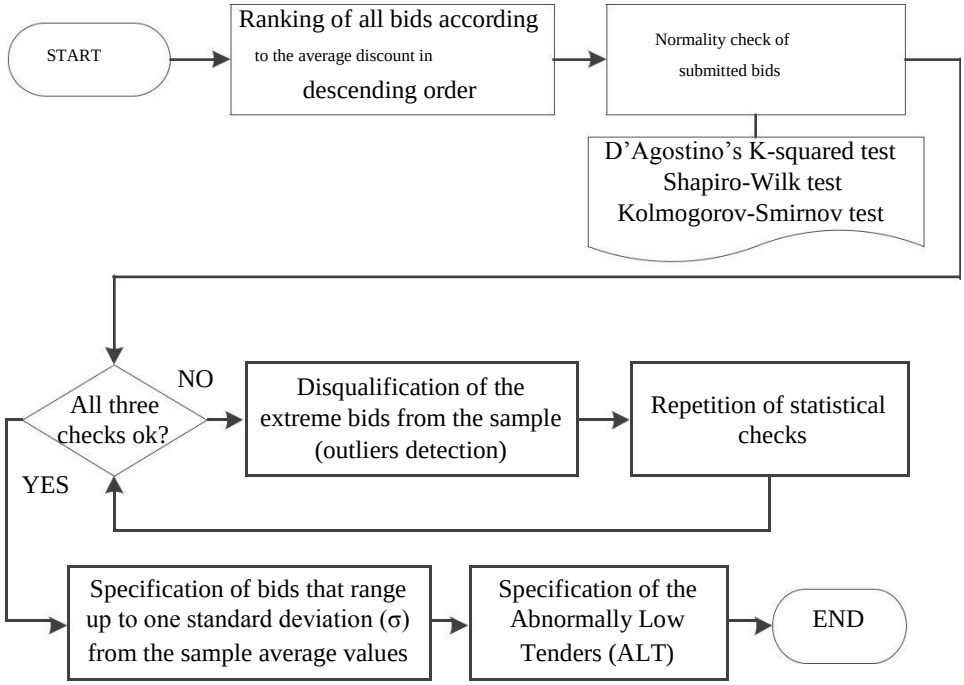

Figure 1: Research Framework

4. Case Study

The sample of projects that were used for the implementation of the proposed algorithm comprised 46 public projects which covered a wide spectrum of civil engineering works (e.g. building, highway, hydraulics, marine). The sample was divided in three sub-groups as dictated by the Greek classification system based on the projects' budget. More specifically, the first group comprised projects up to 1,500,000€ (8 tenders). The second group entailed projects up to 7,500,000€ (14 tenders) and the third group included all projects above the aforementioned limit (>7,500,000€, 24 tenders). Three representative examples of tendered projects from each category are presented below (Table 3). In the first case, the normality check was successful. The average bid was estimated at 185,323.69€ and the standard deviation at 35,221.74€. Therefore, the results of the PCL specification yielded $b_{abn} = b_m - s$ = 185,323.69€ - 35,221.74€ = 150,101.96€ (discount rate 61.68%). Therefore, the first three offers are ALT and should be further investigated. In a similar fashion, in Case 2 the PCL was found at 3,197,194.76€ (discount rate 46.78%) which meant that the first six offers (52.20%; 52.05%; 49.56%; 48.20%; 47.76%; 47.09%) are ALT. Case 3 is more complicated, because the normality check on the sample was unsuccessful. Therefore, the lowest bid (highest discount rate of 51.88%) was excluded and the test was repeated, yielding negative results. Next, the highest bid (lowest discount rate of 14.85%) was eliminated from the sample and the statistical checks were successful. The PCL was set at 14,098,213.12€ (discount rate 45.57%), meaning that the first six offers (51.88%; 51.18%; 49.30%; 47.10%; 45.79%; 45.70%) are ALT.

An overview of the checks on the third category of projects is presented in Figure 2. Each column represents a tender, while the initial budget is noted below the X-axis. The offers that were excluded due to the failure of the statistical checks are noted in orange, while the ALT offers are coloured in red. It should be noted that the statistically excluded offers which belong to the lowest part of the columns (i.e. low discount rates) are not further investigated for self-explanatory reasons.

Table 3: Proposed method implementation on selected tenders in Greece

Case	1
Project type	Building (school complex construction)
Budget	399,810€
Bidders	17
Discount rates:	66%; 65%; 64%; 61%; 61%; 59%; ;59%; 57%; 55%; 54%; 54%; 52%; 45%; 42%; 41%; 40%; 37%
Case	2
Project type	Hydraulics (sewage construction)
Budget	6,007,000 €
Bidders	25
Discount rates:	52.20% ; 52.05%; 49.56%; 48.20%; 47.76%; 47.09%; 44.61%; 42.44%; 42.05%; 41.93%; 41.10%; 39.65%; 38.97%; 33.39%; 32.75%; 32.00%; 31.09%; 30.73%; 29.44%; 28.65; 26.47%; 25.39%; 21.47%; 20.75%; 15.79%
Case	3
Project type	Hydraulics (irrigation channel construction)
Budget	25,900,000 €
Bidders	29
Discount rates:	51.88% ; 51.18%; 49.30%; 47.10%; 45.79%; 45.70%; 44.91%; 44.53%; 43.63%; 43.00%; 42.60%; 42.13%; 41.39%; 40.51%; 39.83%; 39.52%; 38.88%; 38.74%; 37.52%; 36.99%; 36.06%; 35.52%; 35.21%; 35.12%; 35.01%; 34.83%; 33.49%; 26.63%; 14.85%

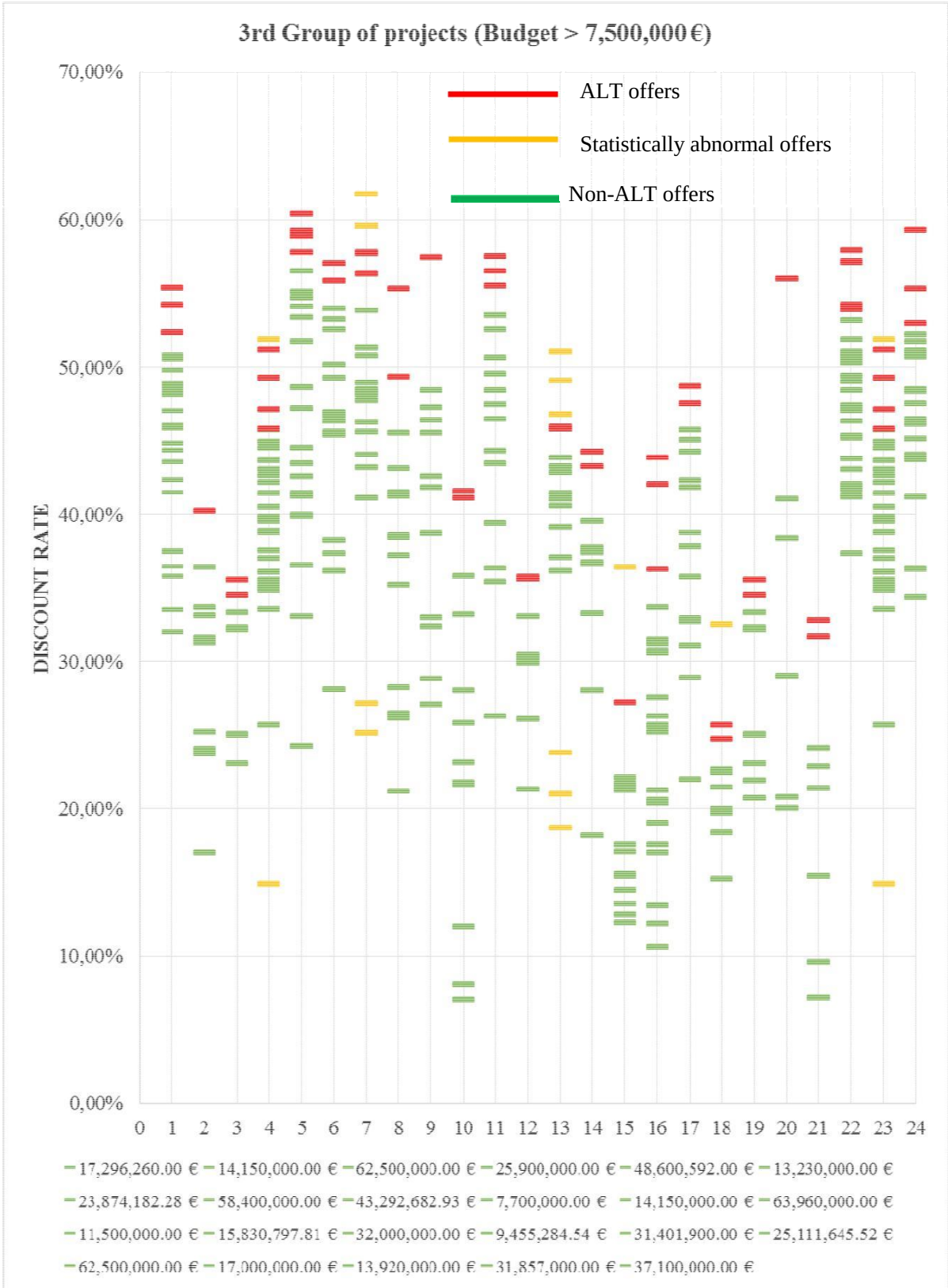
3rd Group of projects (Budget > 7,500,000 €)
ALT offers
Statistically abnormal offers
Non-ALT offers
DISCOUNT RATE
70,00%
60,00%
50,00%
40,00%
30,00%
20,00%
10,00%
0,00%
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
17,296,260.00 € 14,150,000.00 € 62,500,000.00 € 25,900,000.00 € 48,600,592.00 € 13,230,000.00 €
23,874,182.28 € 58,400,000.00 € 43,292,682.93 € 7,700,000.00 € 14,150,000.00 € 63,960,000.00 €
11,500,000.00 € 15,830,797.81 € 32,000,000.00 € 9,455,284.54 € 31,401,900.00 € 25,111,645.52 €
62,500,000.00 € 17,000,000.00 € 13,920,000.00 € 31,857,000.00 € 37,100,000.00 €

Figure 2: Proposed method implementation for project budgets over 7,500,000€

5. Discussion and conclusions

The European Directives dictate that a tenderer who submits an Abnormally Low Tender should provide an explanation to the contracting authorities justifying its bid. Then, "*the contracting authority shall assess the information provided by consulting the tenderer. It may only reject the tender where the evidence supplied does not satisfactorily account for the low level of price or costs proposed*" (European Union, 2014; Article 69, §3). Therefore, even if an acceptable way to determine an ALT is agreed amongst the construction operatives, there has to be an equally objective and acceptable method to determine the criteria according to which the contractors' justifications are going to be formulated. This study proposes three conditions for the justifications:

- **Submission of a project handbook:** Each contractor should submit in written form a handbook that will analytically describe major project parameters, such as innovative construction methods, project environment analysis, WBS/OBS charts, organization structure.

- **Baseline time schedule and cost plan:** The contractor should submit a time schedule that has to be explicitly associated with the resources that are intended to be deployed. In addition, the time schedule should be accompanied with a cost plan, which will allocate the main project costs per activity (e.g. direct, indirect, overheads).

- **New tender documents and enhanced supervision:** Lastly, in an attempt to protect the contracting authorities against an unreliable contractor, it is proposed to replace/enhance the original tender documents with the documentation mentioned in points (a) and (b) above. In this manner, a contractual obligation for the high-risk contractor is established. In addition, if deemed necessary, a special supervising committee could be formed which will provide the required supervision resources or expertise to the contracting authorities throughout the duration of the project.

This study has presented a practical and easy-to-implement algorithm for the detection of ALT. Its simplicity presents an advantage over other more complicated proposals, because it can be readily applied by the contracting authorities without special education or training. It should be stressed, that the method leads to a drop in the average discount rates of 5-10%, leading to a rationalization of the submitted offers. Of course, the selection of a lower λ parameter (e.g. λ=0.5) would make the method stricter and result in even lower discount rates. The study has highlighted the gap in European legislation regarding the way ALT should be justified and, hence, has proposed an indicative structure for the compilation of the necessary documentation. On any case, the increased competition in view of the economic crisis makes the elimination of ALT a necessity not only for the construction industry per se, but also as a prerequisite for growth.

6. References

Ballesteros-Perez, P. and Skitmore, M. (2016). "On the distribution of bids for construction contract auctions", *Construction Management and Economics*, Online at: http://dx.doi.org/10.1080/01446193.2016.1247972 , Accessed on Novemebr 16, 2016.

Ballesteros-Perez, P., Skitmore, M., Das, R. and del Campo-Hitschfeld, M.L. (2015a). "Quick abonormal-bid-detection method for construction contract auctions", *Journal of Construction Engineering and Management*, Vol. 141, No. 7, 04015010.

Ballesteros-Perez, P., Skitmore, M., Pellicer, E., and Carmen, M. (2015b). "Scoring rules and abnormally low bids criteria in construction tenders: a taxonomic review", *Construction Management and Economics*, Vol. 33, No. 4, pp 259-278.

European Union (1999). *Prevention, Detection and elimination of Abnormally Low Tenders in the European Construction Industry*. Reference DG3 alt wg 05, dated 02 May 1999, European Commission.

European Union (2004). *Directive 2004/18/EC of the European Parliament and of the Council of 31 March 2004*. On the coordination of procedures for the award of public works contracts, public supply contracts and public service contracts.

European Union (2014). *Directive 2014/24/EU of the European Parliament and of the Council of 26 February 2014*. On public procurement and repealing Directive 2004/18/EC.

Hu, A., Offerman, T. and Sander, O. (2011). "Fighting collusion in auctions: An experimental investigation", *International Journal of Industrial Organization*, Vol. 29, No. 1, pp. 84-96.

Kutner, M. H., Nachtsheim, C. J., Neter, J., and Li, W. (2005). *Applied linear statistical models*. Mc-Graw Hill, New York.

Law 3669 (2008). *Legislation for public projects construction*. Official Government Gazzette Issue A 116/18.6.2008, Greece.

Law 4412 (2016). *Public contracts for projects, supply and services*. Official Government Gazzette Issue A 147/8.8.2008, Greece.

Megremis, A. (2014) "Abnormally low tenders: objectifying detection.Working towards economically sustainable procurement through a framework for the contracting authority to objectify the detection of abnormally low bids", TU Delft, Online at: uuid:76eb4027-f171-44a8-bd85-34f46007f7ec , Accessed on October 10, 2016.

Murat, G. and Volkan, K. (2008). "Abnormally Low Tender problem in public works", *Proceedings of the 2008 International Conference on Management Science and Engineering*, September 10-12, Long Beach, USA, pp. 1748-1753.

Oviedo-Haito. R.J., Jimenez, J., Cardoso, F.F. and Pellicer, E. (2014). "Survival factors for subcontractors in economic downturns", *Journal of Construction Engineering and Management*, Vol. 140, No 3, 04013056.

Skitmore, M. (2002). "Identifying non-competitive bids in construction contract auctions", *Omega*, Vol. 30, No. 6, pp. 443-449.

Wang, W.C., Yu, W., Yang, I.T., Lin, C.C., Lee, M.T. and Cheng Y.Y. (2006). "Unit-price-based model for evaluating competitive bids", *Journal of Civil Engineering and Management*, Vol. 19, No. 1, pp. 24-36.