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# TREND ANALYSIS OF FINAL CONSTRUCTION PRICES: THE TURKISH CASE

**Savas Bayram**

*Department of Civil Engineering, Faculty of Engineering, Erciyes University, Kayseri, Turkey*
*sbayram@erciyes.edu.tr*

**Abstract**

The 2003 year is accepted as a milestone in the Turkish procurement system. About fifteen years ago, the Public Procurement Law, nr. 4734 enacted instead of the State Procurement Law, nr. 2886. Although the current law was enacted with high expectations, e.g. prevention of the waste of public resources, the number of benchmark field studies conducted under this amendment is limited.
Construction works constitute majority of the Turkish public procurements in monetary terms. This study investigates the trend analysis of the construction prices of public projects. The sample consist a total of 461 public building projects. 272 of these projects were procured in accordance with the State Procurement Law, nr. 2886 and 189 were procured in accordance with the Public Procurement Law, nr. 4734. These projects were completed in three metropolitans of Turkey as; Adana, Ankara and Gaziantep. Data of; completion month-year, contract price and final price of all these projects were collected. Trend analysis of the construction prices of the projects were performed separately for both procurement laws using Mann-Kendall analysis and Spearman's rho analysis. Increasing trends have been observed for both contract prices and final prices of the building projects. It was found that the signs of the financial crisis lived in November 2000 and February 2001 in Turkey could be read much earlier in the Turkish construction sector investments.

**Keywords:** Construction works, final price, Mann-Kendall, procurement, Spearman's rho, trend analysis**.**

## 1. Introduction

The economies of the developing countries are generally depends on the construction sector. Tendering procedures, the unique procurement method of the public employers, also play a significant role in preventing public losses. The 2003 year is accepted as a milestone in the Turkish procurement system as the Public Procurement Law (Law no: 4734, hereinafter PPL) instead of the State Procurement Law (Law no: 2886, hereinafter SPL) has been valid in this year. Although the PPL has been valid since more than 15 years, the field studies related to

this procurement system change is limited. Table 1 shows the most current quantities and the prices of the public procurements in Turkey. These values belong to the 2017 year and have been published by the Turkish Public Procurement Authority [1].

**Table 1.** Summary of the Turkish public procurement types in the 2017 year [1].

| **Procurement Type** | **Quantity of the Public Procurement (*pcs*)** | | **Price of the Public Procurement (*Thousands, ₺*)** | |
|---|---|---|---|---|
| | 2017 year | % | 2017 year | % |
| Goods | 35,158 | 39.36 | 30,101,939 | 14.31 |
| Construction Works | 21,369 | 23.93 | 131,045,991 | 62.31 |
| Services | 32,494 | 36.38 | 48,025,258 | 22.84 |
| Consultancy | 294 | 0.33 | 1,126,592 | 0.54 |
| **TOTAL** | **89,315** | **100.00** | **210,299,779** | **100.00** |

It is clear from Table 1 that although the largest quantity belongs to goods procurement, the largest expense belongs to the construction works. As a developing country as mentioned, Turkish public employers allocate considerable budget to the construction works. This fact indicates that the prices of the Turkish construction works must be precisely examined.

The adverse effects of construction conflicts and disputes include cost overruns, complicated relationships, reduced profitability, low productivity, project delays, costly litigation, and other indirect opportunity costs [2, 3]. Construction cost estimation, one of the most significant parameters for the project success, includes uncertainty. Past research has developed numerous methods to address varying types of uncertainty [4]. However the trend analysis, the method used in this study, has usually found the field of use in Hydraulics division of Civil Engineering. There are studies for the trend analysis of precipitation, evaporation, streamflows etc. See for example Karabulut and Cosun (2009); Çıtakoğlu et al. (2017); Yerdelen (2013) [5, 6, 7]. Trend analysis in Construction Management division of Civil Engineering is lacked and generally used in financial issues. For example, Öcal et al. (2007), used the financial data of 28 Turkish construction firms for the trend analysis. They applied factor analysis method to determine the financial indicators that could be used to analyze the financial trend of the construction industry [8]. Nevertheless the use of trend analysis in construction prices is limited. A current literature review is presented below.

Buchholtz (2016); developed the Monte Carlo simulation and provided a new cost estimation tool with potential utility for preliminary construction cost estimation [4]. Alashwal and Chew (2017); presented the results of the implementation and barriers of cost simulation techniques based on the perception of professionals working in construction projects in Malaysia [9]. Promoting the application of the techniques to attain the other benefits of cost management during project planning and control was suggested. Chege (2017); purposed determining the relationships between construction costs, inflation rate, financing costs and housing supply in Kenya [10]. Statistical software was used to perform trend analysis. It was found that there is a negative relationship between construction costs, financing costs and housing supply and a positive relationship between inflation rate and housing supply [10]. Suveka and Shanmuga Priya (2017); discussed the function of artificial neural network and trend analysis prediction tools for the prediction of construction material prices. Prices of aluminium were collected for the period from 2000 to 2015. The result of the study proved that the artificial neural network is the best predicting tool [11].

This study investigates the changes of the construction contract values and the final prices in Turkish public sector. Trend analysis was carried out to determine whether there is a trend or not for the public school buildings. Mann-Kendall test and Spearman's rho analysis were used for trend analysis. Pettitt's test was also used to determine the start time of the trend.

## 2. Method

Since the financial structures of the organizations directly affect their competitiveness, the most frequently method within the scope of sectoral analysis is financial analysis. As a basis for financial analysis; traditional and mathematical methods as well as current methods such as artificial intelligence and fuzzy modeling methods have been increasing in use [12]. A general classification is presented below;

- Traditional methods (ratio analysis, trend analysis, percentage analysis etc),
- Mathematical methods (multi-criteria decision making methods etc),
- Artificial intelligence and fuzzy modeling methods (artificial neural networks, ANFIS, fuzzy decision support method etc).

Trend analysis, mentioned as a traditional method, is based on the idea that what has happened in the past gives the manager an idea of what will happen in the future [11]. Trend analysis is a technique that uses historical records of the results and data to predict future outcome. The predicted outcome is achieved by tracking variances in the considered parameter's performance. There are three main types of trends as; short, intermediate and long term. Trend analysis calculates the percentage change for one account over a period of time of two years or more [11]. This actually means that the study period should be kept long as the proportional interpretation can provide the expected benefit. Trend analysis is a dynamic analyze type as it considers the movements and the changes [13]. Trend analysis can be replicated, checked, updated and refined when necessary [11].

For the estimation of time series; where *y: dependent variable* and *x: independent variable*, three different functions, respectively linear, parabolic and exponential, is used;

$$y = a + bx \quad (1)$$

$$y = a + bx + cx^2 \quad (2)$$

$$y = ab^x \quad (3)$$

The trend analysis related studies are generally performed for these three functions. Best-fitting to the existing time series among these functions is selected. Optimal function has the minimum estimated standard error ($S_{yx}$).

$$S_{yx} = \sqrt{\frac{\sum y^2 - a\sum y - b\sum xy}{n-2}}, n > 30 \quad (4)$$

The methods used to determine the trend of a series are classified as parametric and non-parametric according to whether the series is distributed or not [14].

### 2.1 Mann-Kendall Test

Mann-Kendall trend analysis is a commonly used non-parametric trend analysis method [15, 16]. This method considers the sorted data of "$x_1$, ..., $x_n$" as 'random variables that are independent of time and have similar distribution' according to null hypothesis ($H_0$). Inverse of the null hypothesis is the alternative hypothesis ($H_1$). According to alternative hypothesis; 'providing ($i \neq j$), the distributions of $x_i$ and $x_j$ are not similar for all ($i, j \leq n$)'. In this context the Mann-Kendall statistic ($S$) can be calculated [6].

$$sgn(x_j - x_i) = \begin{cases} 1; if\ x_j > x_i \\ 0; if\ x_j = x_i \\ -1; if\ x_j < x_i \end{cases} \tag{5}$$

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} sgn(x_j - x_i) \tag{6}$$

In case of the number of data, $n$ greater than 10, a zero-mean variance value [$Var(S)$], which fits the normal distribution is calculated; in which $p$ is the number of the tied groups in the data set and $t_j$ is the number of data points in the $j^{th}$ tied group. The following Z-transformation is then performed.

$$Var(S) = \frac{n(n-1)(2n+5) - \sum_{i=1}^{p} t_i(t_i - 1)(2t_i + 5)}{18} \tag{7}$$

$$Z = \begin{cases} \frac{S-1}{\sqrt{Var(S)}}; if\ S > 0 \\ 0 \qquad\quad ; if\ S = 0 \\ \frac{S+1}{\sqrt{Var(S)}}; if\ S < 0 \end{cases} \tag{8}$$

In case of the calculated $Z < Z_{critical}$ then the null hypothesis ($H_0$) is accepted and vice versa. The direction of the trend is determined as increasing if ($S$) value is (+).

### 2.2 Spearman's Rho Test

Spearman's rho is a non-parametric test which assesses how well the relationship between two variables can be described using a monotonic function [17]. A perfect Spearman correlation of (+1) or (−1) occurs when each of the variables is a perfect monotone function of the other. (+1) shows a perfect positive correlation between ranks while (−1) is a perfect negative correlation and zero means that there is no correlation. The null and the alternative hypotheses are constructed as mentioned in Mann-Kendall test. Spearman rank correlation coefficient ($r_s$) and Z-transformation can be calculated as follows;

$$r_s = 1 - \frac{6[\sum_{i=1}^{n}(R(x_i) - i)^2]}{(n^3 - n)} \tag{9}$$

$$z = r_s\sqrt{n-1} \tag{10}$$

In case of the calculated $Z < Z_{critical}$ then the null hypothesis ($H_0$) is accepted and vice versa. The direction of the trend is determined as increasing if ($r_s$) value is (+).

### 2.3 Pettitt's Test

Pettitt's Test, defined as a non-parametric ranking method, was developed to determine the time period of a change in a time series [19]. Pettitt's Test can identify the point of change on a monthly or yearly scale. The related studies indicate that Pettitt's Test is more sensitive to breaks in the middle of a time series [20, 21]. Also Pettitt's Test does not assume that the series is normally distributed as it is based on the ranks of the elements of a series rather than the values themselves [21]. Therefore the starting points of the increasing trends in this study have been determined using Pettitt's Test.

$$X_K = 2\sum_{i=1}^{k} r_i - k(n+1), \quad k = 1,2,\dots,n \tag{11}$$

$$X_E = \max_{1\le k\le n} |X_K| \tag{12}$$

The ranks; $r_1,\dots,r_n$ of the $Y_1,\dots,Y_n$ are used to calculate the statistics as in Eq. (11). The calculated $X_k$ values are depicted in the graphs representing the results of the Pettitt's Test. If a break occurs in year $E$, then the statistic is maximal or minimal near the year $k=E$ as in Eq. (12).

## 3. Application and Results

The sample of this study for the trend analysis consist a total of 461 Turkish public school building projects. 272 of these projects were procured in accordance with the SPL, nr. 2886 and 189 were procured in accordance with the PPL, nr. 4734. These projects were completed in three metropolitans of Turkey as; Adana, Ankara and Gaziantep. Although these top-ten metropolitans are located in different geographic regions of Turkey, they are relatively close to each other to eliminate regional differences, e.g. raw material supply as much as possible. Detailed information is provided in the Figures 1 and 2.

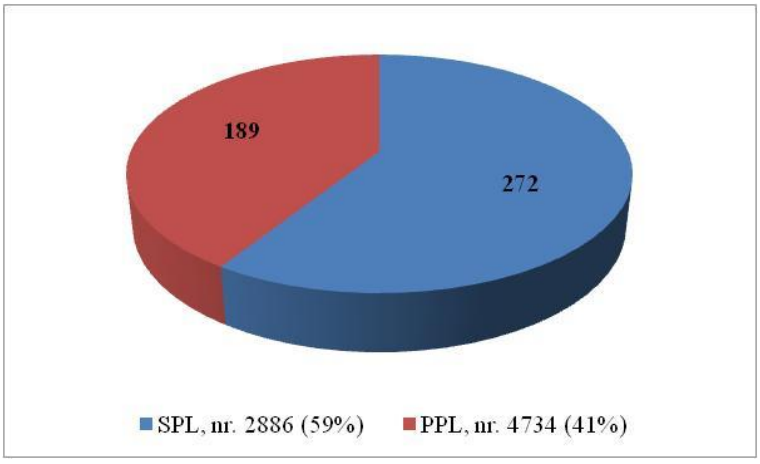


**Figure 1.** Procurement types of the public building projects; N=461

The 59% of the building projects of the sample based on SPL were completed between the 1995 and 2004 years. The remaining 41% based on PPL were completed between the 2004 and 2010 years. Therefore we have a total of 15-year time range towards the period should be kept long as mentioned for the trend analysis.

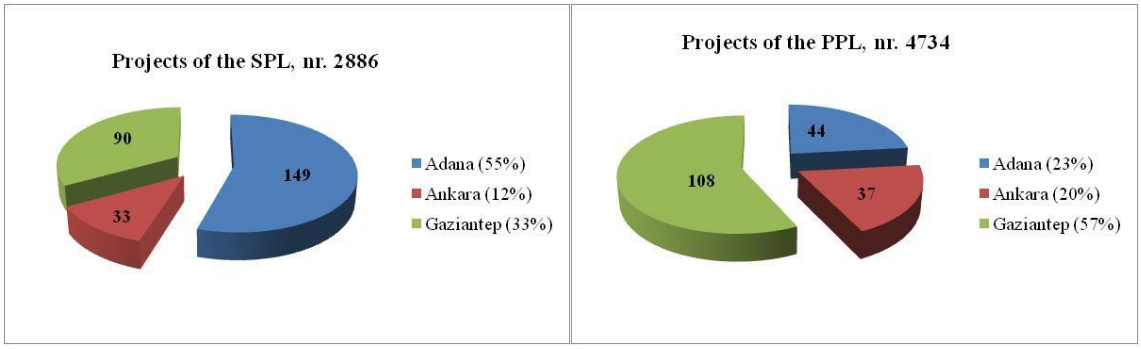


**Figure 2.** Distribution of the projects by the location

The projects completed in Adana represent the majority of the sample based on the SPL, nr. 2886. The projects completed in Gaziantep on the other hand represent the majority of the sample based on the PPL, nr. 4734. In total 43% of the sample belongs to Gaziantep, 42% to Adana and 15% to Ankara. Data of; completion month-year, contract value and final price of all the projects of the sample were collected. Trend analysis of the contract values and the final prices of these projects were performed independently using Mann-Kendall analysis and Spearman's rho analysis. Thus the consistency of the different methods used would also be compared. Pettitt's test was then used to determine the start time of the trend.

### 3.1 Mann-Kendall Test

Classical statistical hypothesis testing involves the testing of a null hypothesis and in most cases the null hypothesis is that there is no effect [18]. Therefore the sorted data of "$x_1$, ..., $x_n$" in this study were considered as 'random variables that are independent of time and have similar distribution' according to the mentioned null hypothesis ($H_0$). The level of significance (α) on the other hand was selected as 0.05. As the calculation involves the two tails of the test statistic distribution, this is generally called two-tailed or two-sided testing [18]. A two-tailed test with a significance level of 0.05 indicates that half of the (α) to testing the statistical significance in one direction and another half to testing statistical significance in the other direction. This means that (α)/2= 0.025 is in each tail of the distribution of the test statistic.

Mann-Kendall statistics ($S$) for the projects of each metropolitan were calculated from Eq. (5) and (6). The *Z-values* were then calculated from Eq. (7) and (8). These calculations were independently performed for the contract values and the final prices.

**Table 2.** Mann-Kendall trend analysis for the contract values; N=461.

| Region | Number of Data (n) | Mann-Kendall-Statistics (S) | Z | Result |
|---|---|---|---|---|
| Adana | 193 | 1,128 | 8.645 | **Increasing Trend** |
| Ankara | 70 | 394 | 6.089 | **Increasing Trend** |
| Gaziantep | 198 | 1,957 | 8.947 | **Increasing Trend** |

**Table 3.** Mann-Kendall trend analysis for the final prices; N=461.

| Region | Number of Data (n) | Mann-Kendall-Statistics (S) | Z | Result |
|---|---|---|---|---|
| Adana | 193 | 1,130 | 8.660 | **Increasing Trend** |
| Ankara | 70 | 368 | 5.686 | **Increasing Trend** |
| Gaziantep | 198 | 1,875 | 8.572 | **Increasing Trend** |

A significance level of 95% aforementioned was considered for all the analyses and this result in a *critical Z-value* of 1.96 from the standard normal distribution table. If the *calculated Z-value* is less than the specified significance level, then the null hypothesis of no effect is rejected. For the Tables 2 and 3, all the *Z-values* greater than the $Z_{cr}$, 1.96 indicates that the null hypothesis ($H_0$) was rejected. This means that there is a trend for all the cases. The direction of the trend on the other hand was determined considering the ($S$) value. Since all the obtained S-values are positive, indicates that there is an increasing trend for all the cases.

### 3.2 Spearman's rho Test

Spearman rank correlation coefficients ($r_s$) for the projects of each metropolitan were calculated from Eq. (9). The *Z-values* were then calculated from Eq. (10). These calculations were independently performed for the contract values and the final prices. The details have been provided in the Tables 4 and 5.

**Table 4.** Spearman's rho trend analysis for the contract values; N=461.

| Region | Number of Data (n) | Rank Correlation Coefficient ($r_s$) | Z | Result |
|---|---|---|---|---|
| Adana | 193 | 0.958 | 6.908 | **Increasing Trend** |
| Ankara | 70 | 0.893 | 5.052 | **Increasing Trend** |
| Gaziantep | 198 | 0.870 | 7.487 | **Increasing Trend** |

**Table 5.** Spearman's rho trend analysis for the final prices; N=461.

| Region | Number of Data (n) | Rank Correlation Coefficient ($r_s$) | Z | Result |
|---|---|---|---|---|
| Adana | 193 | 0.956 | 6.892 | **Increasing Trend** |
| Ankara | 70 | 0.856 | 4.844 | **Increasing Trend** |
| Gaziantep | 198 | 0.852 | 7.327 | **Increasing Trend** |

The significance level of 95% as such in the Mann-Kendall analysis was considered for Spearman's rho analysis. For the Tables 4 and 5, all the *Z-values* greater than the $Z_{cr}$, 1.96 indicates that the null hypothesis ($H_0$) was rejected. This means that the results of the Spearman's rho trend analysis correspond with the results of the Mann-Kendall trend analysis. The direction of the trend on the other hand was determined considering the ($r_s$) value. Since all the obtained $r_s$ values are positive, indicates that there is an increasing trend for all the cases. By this point, whether there is a trend or not as well as the direction of the trends have been responded. However there is still one question which refers to the start points of these increasing trends.

### 3.3 Pettitt's Test

At the last stage of the application, Pettitt's Test was used in order to determine the linear slopes, in other words the changes in unit time, of the sample. Figures 3 to 5 seperately represent the graphs for the contract values and the final prices obtained from the metropolitans of Adana, Ankara and Gaziantep respectively.

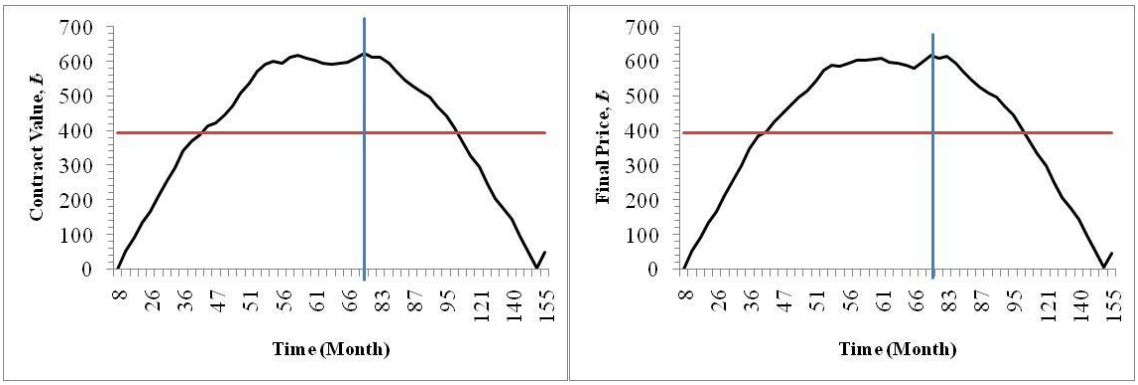


**Figure 3.** Pettitt's Test graphs of the projects from Adana

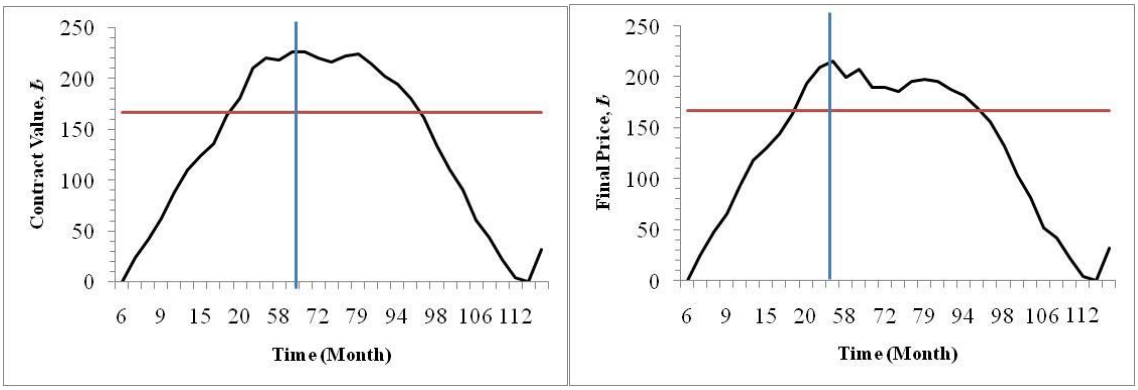


**Figure 4.** Pettitt's Test graphs of the projects from Ankara

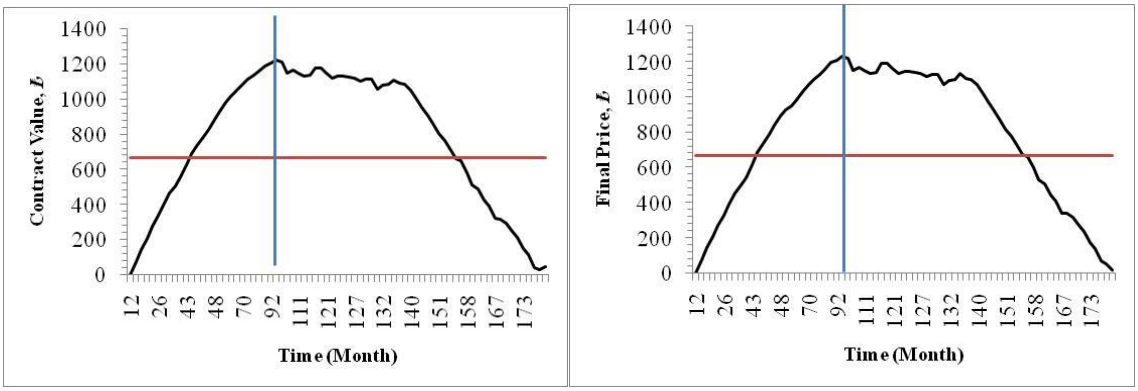


**Figure 5.** Pettitt's Test graphs of the projects from Gaziantep

Figure 3 for Adana shows that the data of completion month-year starts from August 1995. The year 2000 was obtained as the year of change in contract values above the 95% confidence limit. Exactly 71st month corresponds to November 2000, which indicates the start of the increasing trend for the contract values. For the final prices on the other hand, the start of the increasing trend corresponds to the 72nd month, to December 2000.

Figure 4 for Ankara shows that the data of completion month-year starts from June 1995. The year 2000 was obtained as the year of change in contract values above the 95% confidence limit. Exactly 61st month corresponds to March 2000, which indicates the start of the increasing trend for the contract values. For the final prices on the other hand, the start of the increasing trend corresponds to the 48th month, to February 1999.

Figure 5 for Gaziantep shows that the data of completion month-year starts from December 1995. The year 2002 was obtained as the year of change in contract values above the 95% confidence limit. Exactly 90th month corresponds to June 2002, which indicates the start of the increasing trend for the contract values. For the final prices on the other hand, the start of the increasing trend corresponds to the 91st month, to July 2002.

## 4. Conclusion

The findings of this study indicate that for the school building projects of the considered three Turkish metropolitans, trends have been determined for both contract values and final prices. The directions of all the trends are also increasing. These findings indicate that Mann-Kendall trend analysis and Spearman's rho trend analysis of both contract values and the final prices have similar results.

The start points of these increasing trends were determined using Pettitt's Test. Similar results have been obtained from Adana and Gaziantep metropolitans. Namely, soon after the trend starts for the contract value, it also starts for the final price. However the start points of the trends correspond to the end of 2000 year for Adana, whereas they correspond to the mid-year of 2002 for Gaziantep. The reason is evaluated as the two financial crises lived in Turkey; initially in November 2000 and then three months later, in February 2001. In this case, it can be stated that the public financial investments in Adana were instantly affected by these financial crises. Gaziantep was more stable and the public investments were started to be affected after about 1.5 years.

In Ankara, unlike the other two cities, the trend of the final prices started earlier than the trend of the contract values. The trend starts at the beginning of 1999 for the final price while at early 2000 for the contract value. Thus there is 13 months between the start points of the increasing trends. If the initial financial crisis, which began in November 2000 in Turkey, is considered, it is clear that the increasing trend for the final price was started 21 months, approximately two years, before the initial financial crisis. This indicates that the signs of the financial crisis could be read much earlier in the Turkish construction sector investments. Therefore it is essential that the data of construction projects must be collected centrally and that these data should be periodically analyzed and their trends should be examined.

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