The Analysis of the 2008 Global Crisis on the Exports of Turkey

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***Abstract*—Global crisis affects the overall economy, but in some cases even no reduction in production levels occur, exports decline sharply. In this study we attempted to answer the question; if a global crisis had not taken place in 2008, what would be the value of exports in Turkey in 2009? Beside the subject analyzed, another main objective of this article was to present an alternative methodology for analyzing such topics and demonstrate its advantages. For this purpose, by using the annual time series exports data from 1981-2014, we employed Grafted Polynomial Functions and estimated the value of exports in 2009 in a predictive manner. We found that, a loss of approximately $ 54 billion occurred in Turkey's exports as the result of the 2008 global crisis. We also showed the strength of our model in extrapolation and in interpolation by establishing the relationship between B-Splines and our grafted polynomial function.**

***Index Terms*—B-Spline, export, 2008 global crises, grafted polynomial function.**

I. Introduction

The purpose of this study is to measure the impact of the global crisis in 2008 on Turkey's exports. While aiming to achieve this purpose, another main and primary objective of this article is to present (Grafted Polynomial Function, B-Spline) as an alternative methodology that can be used in the analysis of the similar topics which we shall discuss in this study and demonstrate its advantages.

As known, such crisis significantly affect foreign trade the overall economy of countries under the influence. In some cases however, when a global crises occur and production levels does not reduce, huge declines in exports are still expected. Therefore it can be argued that a global economic crises may have direct impact on the exports of a country.

The effects of crisis on economies and their foreign trade, can easily be seen and analyzed in time series data. But generally, when time series covers the period of crisis, it reflects different characteristics and functional structures in those years. In examining the data, it was realized that the time series had a particular trend until a distortion after 2008 Global Crisis.

In time series, broad movements which can be seen as gradual changes, are generally described as trends and they evolve more gradually than do the evident ones. These transitory structured changes are often defined as fluctuations.

In many cases, the trends are regarded as accumulated effects of the fluctuations. But in some cases, the trends and the fluctuations reflect different various influential elements, so we need to decompose the time series into the corresponding components [1].

The most important characteristic of a model which is used in time series analysis is that, it must be flexible enough to reflect the characteristics of the period considered. In order to provide this flexibility, various time series methods and different functional structures can be used. Among these, one of the most advantageous methods is spline function which is known as one -piece polynomial function [2].

In a mathematical spline function, a separate polynomial function chain replaces the flexible strip composed by functions each of degree *n*. Here, separate neighboring functions meet at knots and so therefore fulfil continuity conditions both as functions and in first *n-1* derivatives [3].

B-splines were discussed first by Ref. [4] as equally-spaced knots, in a specific case, and then, 20 years later Ref. [5] reviewed B-splines again. In following years, the use of B-splines in interpolation and smoothing were discussed and analyzed by many authors such as, [6]-[11].

Splines have a greater flexibility and superiority in time series analysis, when compared with single regression Ref. [12] because they provide 'form-free curve fitting' [13]. Splines can also cover data, containing and exposing different behaviors in separate regions which may be unrelated with each other [14]. Generally, some other forms of regression analysis may possess a great capacity in smoothing and interpolation, but their abilities in prediction are weak. Choosing splines as the technique of time series analysis which covers global crisis periods, seems to be more appropriate [15].

So we decided to employ Grafted Polynomial Functions and estimate the value of exports in 2009 in a predictive manner. Additionally, we established the relationship between B-Splines and the grafted polynomial function and applied our model in both interpolation and extrapolation.

In this study, we carried estimations until 2015 because of the unsuccessful coup attempt in Turkey in July, 15. 2016. Many unexpected effects which were mentioned in the conclusion, have been emerged in Turkey's economic and political situation and they affected almost all of the economic data and especially the value of the exports of the country. Accordingly, to clearly identify the impact of the 2008 global crisis became difficult.

II. Exports of Turkey During 1981-2010 Period

In the period before 1980, inward-looking industrialization policies basing on protectionism an import substitution were being implemented in Turkey. But after 1980, implementation of policies aiming closer integration with the

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world economy were put into practice. By removing quantitative restrictions on foreign trade and reducing customs duties to a great extent, important steps were taken towards the liberalization of foreign trade.

After 1980, owing to the neoliberal transformation realized in the country, accession to the world trade had increased significantly and the exports of industrial products rose because of the structural change that have occurred in exports. In contrast, the expected increases in private domestic and foreign investments, production and employment, were not achieved. Furthermore, the improvement of productivity in manufacturing and the recovery of real wages continued to display an unstable trend or path. Priority was given to export companies and sectors in the period. Until the early years of 1990s, a significant amount of cash support was provided for investments through applications such as Incentive and Resource Utilization Support Premium [16].

The exporters or manufacturer-exporters having foreign market knowledge and experience benefited from the "Export Rediscount Credit" which was enacted in 1986. This credit application was later repealed in 1989. However, the implementation of measures to promote exports such as, "tax, charge and Due Exemption in Exports, and deduction from the foreign currency earnings of exports" were continued. Additionally in 1987, the "State Investment Bank" transformed into a joint stock company subject to private law with a new name as "Export Credit Bank of Turkey". In this period significant changes in the import regime was also made. In 1984, Liberation Lists with the numbers I and II were abolished and a transition to a completely new system happened. With the lists created in this new system, the goods which are subject to prohibition or authorization in importation were sorted and the importation of goods which was not mentioned in the lists were released.

As a result of these measures, the proportion of non-agricultural products in exports which was 71% in 1986, reached 79% in 1987. In same years, the ratio of exports to Organization for Economic Co-operation and Development (OECD) countries rose to 63.2% from 57.6%, and the exports to European Economic Community (EEC) also reached to 48% from 44%. Despite these improvements, economic policy after 1980 had created a significant impact on wage and productivity levels. In particular, policies to promote exports, which relied on labor-intensive industries and intended to provide competitiveness by reducing costs in the short term, caused a decline in real wages [16].

During the period of 1990-1999, Turkey, entered in an intermittent crisis atmosphere and the interventions of the Central Bank failed to solve the problems it encountered, and therefore "5 April 1994 Decisions" had become mandatory. In this context, according to the stability program conducted with the IMF, the Central Bank loans to the public was limited [17]. The main aim of this stability program was reducing the public deficit by making significant constraints in public spending and reducing the rate of inflation. In relation with the current account deficit, an import reduction together with an increase in exports was partly realized before and after this program, due to the significantly devalued Turkish Lira against foreign currencies. Indeed, as a result of policies implemented in the first half of 1994, exports increased while imports declined when compared with 1993 [18]. After the 5 April decisions in 1995, Economic Administration of the Country in that period announced that, Turkey had become the fastest growing OECD country with a 7 percent growth rate attained in 1995, 1996 and 1997. Inflation had declined to 2-digit number, an important increase in exports was realized, and the reserves of Central Bank increased [19].

These positive expectations and improvements ended because of a financial crisis experienced on 22nd November 2000. The most important issue raised by this crisis in Turkey, had been the restructuring of the weak and troubled banking system. However, banking restructuring initiatives had created the feeling that the banking system of the country was in a difficult situation because of the high number of failed private banks and some public banks. Furthermore, the banking system continued rapid external borrowings, increasing the demand in the domestic markets and the phenomena of overvaluation of the Turkish Lira caused the stagnation of exports. In addition, the foreign currency inflows reduced because of the overvalued national currency and the fall in the euro/dollar parity. These events affected exports of Turkey negatively and also reduced export revenues in terms of dollars.

While attempting to exit the November 2000 Crisis, on 19 February 2001 a sudden and surprising governmental crisis in the highest level occurred in the country and this event started a strong speculative attack to foreign currency. During this period, the reserves at the Central Bank also suffered a severe loss. Accordingly, on February 21 interbank overnight interest rate had reached to an incredible level in the money market but even this interest rate did not prevent the excessive demand for foreign currency. The difference between the November 2000 and February 2001 crises was that, whiles the former was driven by foreign speculators, the latter was driven by both foreign speculators and Turkish Banks. As a result, the Central Bank reacted by allowing the foreign currency to float.

In the period after 2001 crisis, a decrease in imports and increase in exports was expected as a result of rising exchange rates, but they remained low because of high interest rates, the external debt, and current account deficit continued to grow in the Turkey. In this period, one of the major handicaps of Turkey in getting rid of high external debt and current account deficit problems was that the dependence exports to imports. Real sector, imported cheap intermediate goods by taking advantage of cheap foreign exchange and produced durable goods for exports which were sold to different markets and thus exports became dependent to imports.

Despite these negative situations, Turkey implemented significant economic policies and showed intense efforts in order to overcome the crisis in 2001. Beside these policies and efforts, the improvements in domestic political stability and positive international economic conjuncture helped Turkey in realizing significant improvements and recovering from the negative effects of the crisis. But in the same decade, Turkey was faced with the Global Crisis in 2008. The economic policies applied after the 2001 crisis had positive and relieving effects on the repercussions of the 2008 global financial crisis on the national economy. But, because of the global dimension of 2008 crisis, it must be particularly noted

that a significant negative impact on foreign trade of Turkey emerged [20].

On the other hand, one of the effects of the global crisis in 2008 on the financial markets of Turkey, had been on the foreign exchange and exchange rate policy. According to the floating exchange rate regime which was applied, exchange rates were determined in foreign exchange markets. However, this system could not work well because of the inefficiencies in the financial structures. Hot money inflows and increased borrowings by the private sector after 2003 reduced the pressure on the exchange rates of foreign currencies and they remained low. High interest rates also prevented the rise of the foreign exchange rates, as a result it overturned the export-import balance. Additionally, low exchange rates affected inflation positively but grew current account deficit [21].

It is well known that exports are of great importance in financing the current account deficit and to sustaining economic growth in Turkey. The current account deficit climbed because of the decline in the exports during post-crisis period in the country [22].

In the period between 1981 and 2010, after summarizing the developments that affected Turkey's foreign trade and especially exports briefly, it would be useful to look at the overall export data of this period. When the export values of Turkey in billion dollars is examined, a sudden drop in 2008 is seen clearly in the following graphics.

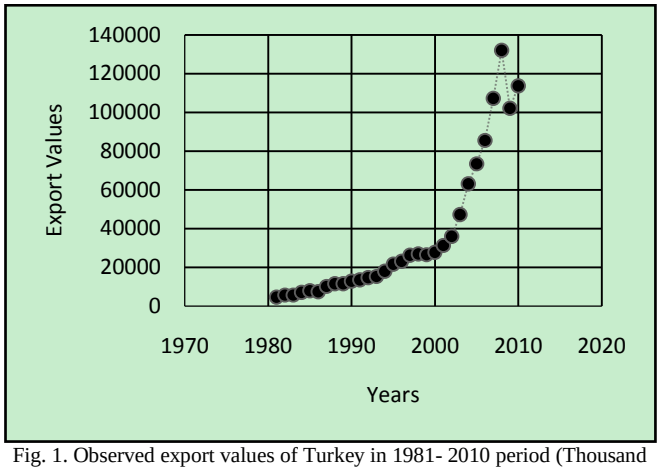

Fig. 1. Observed export values of Turkey in 1981- 2010 period (Thousand American Dollar).
Source: www.tuik.gov.tr

III. Methodology

The methods of splines was first introduced as an alternative to polynomial curve-fitting, or more complicated methods using non-linear least squares where the data to be fitted are obviously beyond the reach of a simple polynomial. Rather than raise the order of polynomial to such a degree that spurious over-fitting took place, with a breakdown in the method of least squares, the original workers in the field considered that a well ordered set of low-order polynomials would be a more effective approach. They encountered two problems; first, positioning the polynomials so that they would best reflect the underlying trends in the data and, second, using apparently discounted and somewhat unrelated polynomials to represented arbitrary subsets of the data. The first was solved by creating variables which fixed the range of each polynomial (not necessarily the same for each element in the chain) and by using low orders of polynomial so that the shape of segment of the data could be reflected without over-fitting. The second problem was overcome by constraining the elements at their common end points to agree in position and slope. This provided a smooth transition from one polynomial to the next, resulting in a satisfactory overall fit, both mathematically and visually [11].

Guided by these general requirements, polynomials of varying degree form spline together. For example, a mixture of straight lines and constants [23], several quadratics [24] or several cubics [14]. In the special application of plant growth studies, where logarithmically-transformed primary data are all but essential, the cubic is the minimum degree of polynomial that can be considered. This is because the first derivative (relative growth rate) must be free to change smoothly with time, that is, there must be continuity also in the second derivative, rate of change of slope. Splines of lower order cannot possess this feature [24].

For this reason, when the dependent variable is plotted according to the independent one, and if a sharp change occurs after a certain time (Time variable X) it would be appropriate to use spline models [2].

A. Grafted Polynomials

A polynomial curve has certain characteristics which may make it inappropriate as a means of modelling a trend. The most notable of these is its behaviour beyond the range of the data [1].

The goal in many studies is to represent a response variable, y, as a relatively simple analytic function of an input variable(s). Most functions furnish only an approximation in a limited range. Thus, in a practical situation, the choice of functional form will rest upon theoretical considerations, ease of estimation and acceptance by the data.

Generally, a function is desired if it

1) is continuous,
2) possesses continuous first derivate,
3) is easy to estimate (i.e., linear in the parameters), and
4) permits easy computation of optima.

Obviously this is not an exhaustive listing of desirable properties, nor are the listed properties of equal importance. One function that satisfies these criteria to an admirable degree is the quadratic. However, the quadratic does not always furnish an adequate approximation over the entire experimental space.

We shall show how it is possible to 'graft' quadratic (and other polynomial) functions to increase the domain of approximation in such a way that Properties 1, 2, and 3, and to a large extent Property 4, are retained.

The grafted polynomials can be used to approximate the trend in a time series. The series may be divided into segments each containing A observations and the trend in each is adequately approximated by a polynomial of degree m. The trend is continuous from period to period and the first r ($r \leq m$-1) derivatives of the trend are continuous.

Let us consider in detail the case when we are willing to approximate the trend by a quadratic with continuous first derivate. Assume the data is indexed by (t= 1, 2,…, n). Dividing the data in segments of A observations, we consider the regression variables:

$$Z_{it} = (t-(i-1)A)^2 \quad t > (i-1)A$$
$$= 0 \quad \text{otherwise} \qquad (1)$$

where $i = 1,2,\ldots,M$ and M = an integer such that $|AM - n| < A$. The series is divided into M segments and $M - 1$ is the number of grafts in our function. We assume that, if $n \neq AM$, the last segment, containing observations indexed by $i = A(M-1)+1, A(M-1)+2,\ldots, n$, is the only one to contain more or less than A observations. At the formal level all we need do to estimate the trend is to regress our series upon $t, Z_1, Z_2,\ldots, Z_M$ the estimate trend being given by

$$\hat{Y}_t = \hat{C}_0 + \hat{C}_1 t + \sum_{i=1}^{M} \hat{d}_i Z_{it} \qquad (2)$$

where $\hat{C}_0, \hat{C}_1$ and $\hat{d}_i$ are the estimated regression coefficients. To reduce the correlation, we suggest that a simple linear combination of the Z's be taken to form the variables

$$X_{it} = Z_{it} - 3Z_{i+1,t} + 3Z_{i+2,t} - Z_{i+3,t} \quad i = 1,2,\ldots,M \qquad (3)$$

where for convenience we define $Z_{M+1} = Z_{M+2} = Z_{M+3} = 0$.

Note that

$$X_{it} = (t-(i-1)A)^2 \qquad (i-1)A < t < iA$$

$$X_{it} = (t-(i-1)A)^2 - 3(t-iA)^2 \qquad iA \leq t \leq (i+1)A$$

$$X_{it} = (t-(i+2)A)^2 \qquad (i+1)A \leq t < (i+2)A$$

$$X_{it} = 0 \qquad \text{otherwise} \qquad (4)$$

with either the Z's or X's, the forecast equation is $y = \hat{b}_0 + \hat{b}_1 t$ where the $\hat{b}$'s are the least squares coefficients.

B. B-Spline

A more sophisticated method of fitting a grafted polynomial uses an alternative set of basic functions which are themselves polynomial splines [1]. These are the so-called B-spline functions.

Definition: B- Splines

$$\cdots \leq y_{-1} \leq y_0 \leq y_1 \leq y_2 \leq \cdots \qquad (5)$$

be a sequence of real numbers. Given integers i and $m>0$, we define

$$Q_i^m(x) = \begin{cases} (-1)^m [y_i,\ldots,y_{i+m}](x-y)_+^{m-1}, if\ y_i < y_{i+m} \\ 0 \qquad\qquad\qquad\qquad , \text{otherwise} \end{cases} \qquad (6)$$

for all real x. We call Q_i^m the mth order B- spline associated with the knots $y_i,\ldots,y_{i+m}$.

In many applications of splines it suffices to work with equally spaced knots. This leads to simplifications in the theory as well as substantial savings in computation. In this section we discuss B- splines with equally spaced knots.

We say that a set of knots $\cdots y_i, y_{i+1}, \cdots$ is uniform with spacing h provided

$$y_{i+1} - y_i = h\ for\ all\ i. \qquad (7)$$

For uniformly spaced knots it turns out that any B- spline can be obtained from one basic B- spline by translation and scaling. Let

$$Q^m(x) = \frac{(-1)^m \Delta^m (x-y)_+^{m-1}}{m!} y = \sum_{i=0}^{m} \frac{(-1)^i \binom{m}{i} (x-i)_+^{m-1}}{m!} \qquad (8)$$

This is the usual B- spline associated with the simple knots 0, 1,…, m. It belongs to $C^{m-2}(-\infty,\infty)$. Associated with Q^m, we also introduce the normalized version [10]:

$$N^m(x) = mQ^m(x). \qquad (9)$$

Power bases are useful for understanding the mechanics of spline-based regression and they can be used in practice if the knots are selected carefully or a penalized fit is used. However, the power bases have the practical disadvantage that they are far from orthogonal. This can sometimes lead to numerical instability when there is a large number of knots and the penalty parameter λ is small (or zero in the case of ordinary least squares). Therefore in practice, it is advisable to work with equivalent bases with more stable numerical properties. The most common choice is the B-spline basis.

Modifying a knot causes a continuous deformation of the B-spline function; the form of the B-spline function is determined by the position of the knots. Increasing the degree of the B-spline function leads to a smoother function (p=1: continuous function; p=2: continuous first derivative; p=3: continuous second derivative). Spline estimation is sensitive to the choice of the number of knots and their position. A knot can have an economic interpretation: specific date, structural change. But some information is required [25].

IV. Application and Results

We shall fit a trend line to the adjusted export data in Turkey 1980-2010 periods. We somewhat arbitrarily assume that, for a segment of 7 years, the trend is adequately approximated by a quadratic path. We approximate the trend for the last 1 year by a straight line used for extrapolation. The trend is required to have continuous first derivatives. Accordingly, the variables

$$Z_{1t} = (t-2008)^2, \quad t < 2008$$
$$= 0 \quad , \text{ otherwise}$$
$$Z_{2t} = (t-2001)^2, \quad t < 2001$$
$$= 0 \quad , \text{ otherwise}$$
$$Z_{3t} = (t-1994)^2, \quad t < 1994$$
$$= 0 \quad , \text{ otherwise}$$
$$Z_{4t} = (t-1987)^2, \quad t < 1987$$
$$= 0 \quad , \text{ otherwise}$$

are constructed.

These were transformed as suggested and

$$X_{1t} = Z_{1t} - 3Z_{2t} + 3Z_{3t} - Z_{4t}$$
$$X_{2t} = Z_{2t} - 3Z_{3t} + 3Z_{4t}$$
$$X_{3t} = Z_{3t} - 3Z_{4t}$$
$$X_{4t} = Z_{4t}$$

together with the variable (t-2009) were used in the regression. The resulting estimated equation is

$$Y_t = 156{,}368.411 + 24{,}757.950(t-2009) + 1{,}546.023X_{1t} + 3{,}213.355X_{2t} + 4{,}907.723X_{3t} + 6{,}641.355X_{4t}$$

When the variables are coded in this manner, we see that the constant term is the forecasted export for the next observation, in our case 2009. The forecast for additional

observations is given by

$$Y_t = 156{,}368.411 + 24{,}757.950(t - 2009)$$

The data and the fitted trend line are plotted in Fig. 2. An example of the use of B-splines in spline regression can be found in Ref. [24] who considered quadratic (m=3) cardinal (equally spaced knots) B-splines for trend removal from time series [26].

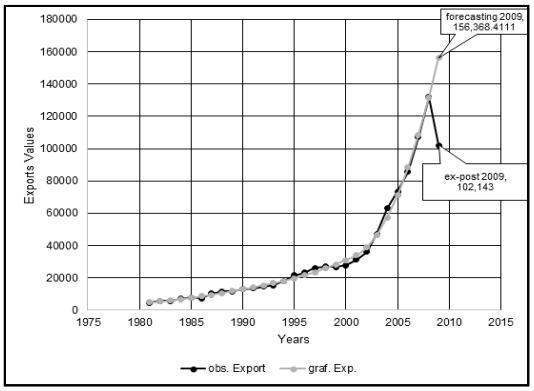

Fig. 2. Observed and forecasted exports values with grafted polynomials function.
Source: Author's calculations

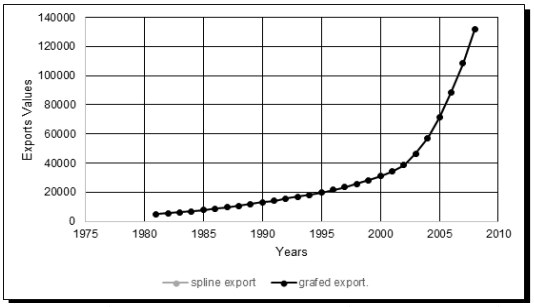

Fig. 3. Estimates of quadratic B Spline and grafted polynomials function of export values.
Source: Author's calculations

Fig. 3 shows the estimated export values which were calculated in two different ways. In addition, these numerical values can be seen in Appendix.

V. Conclusion

We have seen that 2008 Global Crisis had caused a new break in the time series. Hereafter, we continued our analysis by considering this break. First, we created a B-spline model for export values in the 1981-2014 period. The corresponding coefficients of this model are shown in Table I.

TABLE I: B Spline Model for 1981-2014 Period

Coefficients	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)β_0	160,994	6,389	25.198	< 2e-16***
β_1	-157,070	9,066	-17.325	8.45E-16***
β_2	-150,992	10,424	-14.486	5.81E-14***
β_3	-159,016	10,822	-14.693	4.18E-14***
β_4	-133,037	9,208	-14.448	6.18E-14***
β_5	-149,392	10,100	-14.791	3.58E-14***
β_6	-40,948	9,484	-4.318	0.000203***
β_7	-23,114	12,356	-1.871	0.072696***

Significant codes: 0 '***' 0.001 '**' 0.01 '*';
Residual standard error: 7,048 on 26 degrees of freedom
Multiple R-squared: 0.9848,
Adjusted R-squared: 0.9807
F-statistic: 239.9 on 7 and 26 DF, p-value: < 2.2e-16
Source: Author's calculations

Here, the effects of 2008 Global Crisis can be discussed under two different (cases) situations. When the Fig. 4 is examined, it can be seen that the observed and estimated export data are separated from each other after 2006. In first case, the effects of the crisis can be considered to start from 2007. So as the crisis began in the United States, some measures were taken at the company level in Turkey and this practice may have continued in 2008. The total impact of the crisis in the 8-year period from 2007 to 2014, can be calculated in the form of an increase as to be about $ 8.619.000.

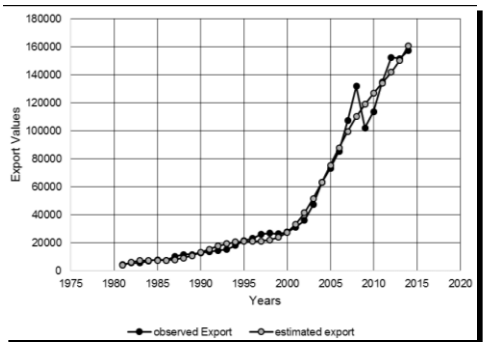

Fig. 4. Observed and estimated exports values with B Spline model.
Source: Author's calculations

Referring to Fig. 4 again, a significant drop in exports in 2009 is observed. In the second case, the total impact of the crisis in 2009-2014 as a 5-year period, can be estimated to have caused a $ 20.828.000 loss in exports. As a result, the effects of the 2008 global crisis in Turkey can be considered to start in 2009. These changes can be seen in the table below.

TABLE II: Situation 1 and Situation 2

Years	Observation Export (Thousand American Dollar)	Quadratic B- Spline Export	Differences of Export (2007-2014) Situation 1	Differences of Export (2009-2014) Situation 2
2007	107,272	99,650.838	7,621.162	-
2008	132,027	110,201.482	21,825.52	-
2009	102,143	119,111.350	-16,968.4	-16,968.4
2010	113,883	126,876.808	-12,993.8	-12,993.8
2011	134,907	134,222.834	684.166	684.166
2012	152,462	141,874.409	10,587.59	10,587.59
2013	151,803	150,556.512	1,246.488	1,246.488
2014	157,610	160,994.123	-3,384.12	-3,384.12
Quadratic B-spline Total Differences of Export			**8,618.644**	**-20,828**

Source: Author's calculations

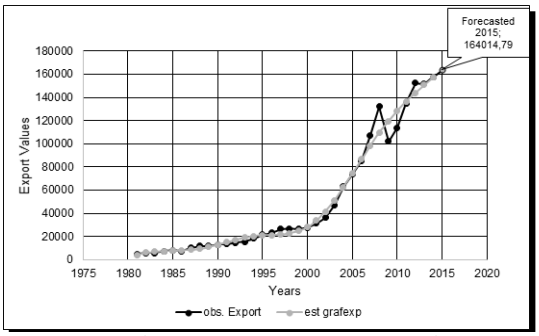

Fig. 5. Observed and forecasted exports values with grafted polynomials function.
Source: Author's calculations

Spline models are quite successful in terms of interpolation because of their flexible continuous functional structures and

they carry the historical trending information as well. Therefore, they can be used to measure the impact of the crisis. However, in deriving the extrapolation values especially in forecasting, using grafted polynomial functions will be better. Our calculations in this manner are shown in Fig. 5.

The data and the fitted trend line are plotted in Fig. 5.

When the variables are coded in this manner, it can be observed that the constant term is the forecasted export for the next observation, in our case 2015. The forecast for additional observations is given by

$$Y_t = 164{,}014.79 + 6{,}608.07(t - 2015)$$

Turkey's exports in 2015 is expected to be $ 164.014.000, under the influence of the 2008 global crisis.

Here, there were two important reasons to end the forecasts for the future in 2015.

First, the government started to follow different policies in 2006 at the Turkish border of Iraq and Syria in line with the transformation and transformation process in the Middle East. The power balances in this region changed continuously and the international political relations of Turkey varied depending on them. Thus, changing international political relations also affected export values sharply. Moreover, the unsuccessful military coup attempt in Turkey on July 15, 2016 caused strong and sudden effects on Turkey's economic and political situation and almost all of the economic data and especially the value of the exports of the country decreased. Moreover, after this date, the government increased the fight against terrorism, especially at home and on the border of Iraq and Syria for border security. Because of these activities the government started to spend a great deal of money for defense and had to endure continuous and large costs. So, after 2015 it became impossible to talk about and forecast the net or pure impact of the 2008 global crisis.

Second, in this study we specifically aimed to introduce the relation between grafted polynomials and Quadratic B-spline by applying both of them on export data which is a time series and to demonstrate their functionality.

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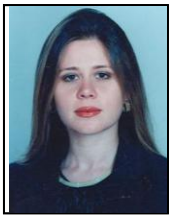

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