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An investigation of export–import ratios in Turkey using spline regression models

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ABSTRACT

This paper examines the use of spline functions in linear, squared, and cubic spline regression models and exhibits the estimation of spline parameters from data by ordinary least squares. Determination of the number and the location of knots is central to spline regression. In this paper, we initially propose a method based on the coefficient of determination R^2 related to the estimation of knots in spline regression. This proposed method as applied to export–import ratio distributions in Turkey for the years 1923–2010 determines the knots, and linear, quadratic, and cubic spline regression models are established accordingly. Results reveal that spline regression models offer better results than polynomial regression models, and that the quadratic spline regression model is the best explanatory model for export–import ratio distributions in the smoothest spline regression models.

1. Introduction

Export/import coverage ratios fluctuate in many ways. The monetary, fiscal, and exchange rate policies of the government, and the amount of exports and imports which result from these policies in combination with foreign economic conditions, all impact on these fluctuations. In the early years of the proclamation of the Turkish Republic (after 1923), agriculture was at the forefront, and the Turkish economy had the characteristics of an obviously open and raw-material-dependent system. Between 1923 and 1928, the level of exports showed a positive trend due to the increasing demand for agricultural products in parallel with favourable weather conditions. However, the proposed import-substitution industrialisation policy, designed to decrease the dependency of industry on imports, failed due to the severe provisions of the Treaty of Lausanne. The agriculture sector was unfavourably affected by the Great Depression in 1929 and the excessive decline in agricultural prices decreased exports by 15% compared to the previous year. After 1929, imports increased by 9% through a successful stockholding policy by importers who claimed an increase in customs tariffs. The Great Depression continued to impact on Turkish exports between

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1929 and 1932, again because of the contraction in agricultural products for export and the decline in prices. Exports tended to decrease until the end of the Great Depression in 1933, and only began to increase in 1938. Similarly, because of the increase in customs tariffs and government policies designed to protect domestic industry, imports also decreased after 1930, notably between 1930 and 1932. Consequently, the milestone year for the Turkish economy was 1933, when both exports and imports began to increase.

The main objective of the early years of the Republic was overall industrialisation through the private sector, but this failed because of the difficult prevailing conditions. Statist policies were deployed to accelerate industrialisation after 1932. For this purpose, two consecutive Five-year Industrial Plans were proposed, for 1934 and 1936, with an initial goal of providing import substitutions for basic needs in order to make foreign currency savings. The second plan was not carried out, due to the death of the founder of the republic, Atatürk, in 1938, and the Second World War between 1939 and 1945 (Şahin, 2002). In that period, Turkish foreign trade was no doubt negatively affected by international economic conditions, and policies designed to achieve a foreign trade surplus were welcomed by the Turkish government. During the Second World War, exports increased due to an increase in the demand for agricultural products and Turkish import volumes narrowed because the importing countries were at war. Export–import ratios increased, especially after 1942, because export prices rose more than import prices. The value of the Turkish lira was also high thanks to strict exchange rate policies. In 1946, the excessive appreciation of the lira exposed the county to the first devaluation in its history, when the export–import ratios reached the highest level, 180.5%.

After the Second World War, and especially between 1946 and 1950, Turkish economic policies were revolutionised, while the implementation of liberal economic policies was carefully planned. In 1947, exports increased by 4% while imports increased by an enormous 106%, leading to a sharp decline in export–import ratios. As a result, restrictive, interventionist, and protectionist foreign trade policies were approved, and in this manner, except for 1938, the export–import ratio stood at over 100% between 1930 and 1946. In 1950, a government reshuffle took place subsequent to the election of the Democratic Party. The Democratic Party intended to follow an open policy in order to increase liberalisation within the Turkish economy, while the import-substitution industrial policy was retained with respect to light industry. Exports consistently increased between 1950 and 1953 due to the increase in volumes of agricultural products, alongside four years of desirable climate conditions. Export revenues increased due to the remarkable share of agricultural products within exports generally, and the simultaneous increase in the global price of agricultural products due to the Korean War. The government had to give up import liberalisation in 1953 because of the limitations of foreign exchange reserves. Foreign trade volumes narrowed again between 1954 and 1958 due to economic instability and ongoing foreign exchange troubles. The excessive appreciation of the Turkish lira caused the second devaluation in 1958. Although the substitution of many basic consumption goods was accomplished between 1950 and 1960, unplanned and unbalanced economic growth also characterised that period (Şahin, 2002).

After the military coup of 1960, a transition period began to a planned economy. Five-year Development Plans were revisited starting from 1962, while import-substitution (particularly interim and investment goods) and domestic-oriented industrial policies were again adopted. Similarly, exports largely concentrated on agricultural products. These

industrial policies did not achieve the expected foreign exchange savings, however. The 1970s were characterised by foreign trade deficits, foreign exchange troubles, and unrealistic outsourcing, and all these difficulties together led to the third currency devaluation. For Turkey, which in that period was an oil-dependent country, the excessive increase in oil prices between 1973 and 1974 led to an increase in imports by 34% and 81% in 1973 and 1974 respectively. However, exports increased by 49% in 1973, partly due to an increase in military expenditures, and increased by 16% in 1974. The ongoing increase in the amount of imports between 1974 and 1975 decreased the export–import ratio to 29.6%, and the ongoing increase in oil prices until 1980 caused a three-step devaluation of the Turkish lira in March 1978, April 1979, and June 1979 (Şahin, 2002).

The government launched a 'stability' policy on 24 January 1980. This programme aimed at a transition from an import-substitution policy to an export-oriented industrial policy, and was intended to keep government intervention to a minimum. The Turkish lira experienced three further devaluations on April 1980, June 1980, and November 1980. Mini-devaluations then followed in order to avoid excessive appreciation of the currency. Several steps were taken to increase the amount of exports, including tax refunds and foreign exchange allocation. These steps were successful, leading to an increase in export revenues between 1980 and 1985, alongside an increase in the demand for export products during the Iran–Iraq War. In 1984 the import policy was characterised by liberalisation, and the rate of increase in imports remained slow until 1991 (Şahin, 2002). The sharp increase in the share of manufactured exports in total exports and the diversification of export markets towards neighbouring developing countries in the Middle East and North Africa can be considered as two main characteristics of the Turkish export performance in the 1980s (Barlow & Şenses, 1995).

The period between 1988 and 1993 was oriented towards economic growth rather than economic stability, and inflation rates were extremely high. In 1993, the lowest export–import rate of the post-1981 period was observed (52.1%). The excessive appreciation of the Turkish lira caused a new devaluation in 1994, whereupon exports increased by 18%, while the imports decreased by 21%, and the export–import ratio was 77.8%. Furthermore, a new import regime was imposed on Turkey with the signing of the Customs Union in 1996. The increase in imports was higher than the increase in exports, and the export–import ratio measured 53.2%. The economic crises in the Russian Federation and in Southern Asia negatively affected the Turkish economy in 1998. Economic dumping and devaluation in Southern Asian countries particularly damaged the Turkish economy. Thus the amount of exports increased by 13% in 1997 and 3% in 1998, but decreased by 1% in 1999. The excessive appreciation of the Turkish lira was again called into question in 2000, causing imports to increase by 34% and exports to increase by 4%, with the export–import ratio measuring 51%. The economy was again exposed to devaluation in 2001, when exports increased by 13%, imports decreased by 24%, and the export–import ratio increased to 75.7%.

To sum up, unrealistic exchange-rate policies and the desire to sustain expansionary monetary and fiscal policies, had impacts which caused decreases in imports and increases in exports. This underlying condition can be considered as one of the major reasons for export–import ratio instability. In this sense, the feasibility of more realistic exchange-rate policies such as foreign trade balances will facilitate the elimination of macroeconomic instability (Şahin, 2002). A recent study for Turkey (Çiçek & Elgin, 2011) found that growth in total productivity rather than growth in labour and capital inputs was the main source

of output growth in Turkey over the sample period 1968–2004 and similarly, other work (Halicioglu, 2007) found evidence about a uni-directional causation from exports to industrial production. Aydın, Çıplak, and Yücel (2004) found the real exchange rate to be an important indicator of imports and trade deficit but not exports. Another recent study concerning Turkish exports (Sarıkaya, 2004) found that real exchange rate was not the sole determinant of the export performance in Turkey and suggested that export growth can be sustained even with an appreciating real exchange rate if the decline in the real unit wage can be accomplished. Previous research (Coşar, 2002) found that aggregate export demand was foreign income elastic but real exchange rate inelastic both in the short- and long-run. This result may imply that exchange rate policies may not be successful in improving export growth. Furthermore, prior work (Tekin & Yazgan, 2009) found a complete exchange rate pass-through to export prices in Turkey implying that the Turkish manufacturing sector has the sufficient competitive strength to transmit exchange rate movements into their prices. An earlier work (Saygılı & Saygılı, 2011) put forward the role of global growth pattern in determining the exports of Turkey due to high import and income elasticity of exports, while other previous work (Alıcı & Ucal, 2003; Bilgili, Tülüce, & Doğan, 2012; Klasra, 2011) indicated that foreign direct investments growth is positively associated with export growth. Utkulu and Özdemir (2004)'s findings supported the endogenous growth theory for Turkey which also underlined the association between trade policy, openness and economic growth.

Balance of trade enables a successful comparison among economic situations of several countries in terms of the amount of exports and imports. In fact, if the total amount of exports are more than the total amount of imports in a certain year it refers to a foreign trade excess. In contrast, if the total amount of imports exceed the total amount exports it implies that a foreign trade deficit occurs. At that point, an export/import coverage ratio will be a relatively important indicator to make such a comparison among selected countries. Although there are various factors that may influence the amount of imports and exports, the former is generally associated with the real exchange rate and the national income level and the latter is generally associated with the income level of foreign countries and the real exchange rate (Akbaş & Şentürk, 2013). Export/import coverage ratio is determined by various economic indicators such as real exchange rate, economic growth, energy prices, income changes in trade partners, interest rates, investments, public expenditures, the movement of foreign direct investments and budget deficits, and so on (Çiftci, 2014). There are two major advantages of using the distribution of export/import coverage ratios as an economic indicator. Firstly, the amount of exports and imports are not effected by measurement units. Secondly, the amount of exports and imports are independent from nominal or real values (Bahmani-Oskooee, 1991). As an export/import coverage ratio is a unit-independent measure of foreign trade excess or deficit, it may conveniently provide comparisons among countries in certain sample periods. This study uses spline regression models to estimate the distribution of export–import ratios in Turkey between 1923 and 2010. The study proposes a methodology based on the determination coefficient (R^2) using linear spline regression to determine the number and the location of the knots. The determination of a structural change point in time series data is very crucial to conveniently estimate regression functions and better understand the structural change process (Yang & Song, 2014). In this sense, spline regression models are the generally preferred method for fitting and smoothing the twists and turns of a time line (Marsh & Cormier, 2002). The value of spline regression models has been emphasised through a significant amount of

previous work. Particularly, many earlier studies in applied economics (Berberoğlu, 2012; Budiantra, Ratna, Zain, & Wibowo, 2012; Gallego & Llano, 2014; Greiner & Kauermann, 2007, 2008; Horowitz, Loughran, & Savin, 2000; Hwang & Wu, 2011; Kuepie, Nordman, & Roubaud, 2009; Martín-Rodríguez & Cáceres-Hernández, 2005a, 2005b, 2010, 2012; Osinubi & Olaleru, 2006; Sarvida & Baguio, 2010; Sing, 2010; Williams, 2009; Yang & Song, 2014) frequently used spline regression models and functions when analysing time series data.

2. Methods

2.1. Spline regression models

As Draper, Guttman, and Lipow (1977) note, a frequently occurring problem in data analysis concerns cases where it is desirable to fit a polynomial-type model to some observed data, but where a single polynomial appears insufficient. For some practical applications, lower-order polynomials do not have sufficient flexibility to provide accurate predictive models over the potentially wide range of interest of an explanatory variable (Woods & Lewis, 2006). Furthermore, a linear least square regression technique is unsatisfactory for modelling a non-linear relationship; and problems of higher dimension modelling and multicollinearity also arise for higher-order polynomials (Kommineni, Basu, & Vemuri, 2007). Although most studies assume that the location of the knots are permanent (in other words, known in advance) in order to make accurate estimations, the case of changing plots is also considered. In spline regression, the choice of the location and the number of the knots is an important and difficult problem; this subject therefore requires close study. To take full advantage of the spline regression model, the position and the number of the knots have to be carefully determined (Agarwal & Studden, 1978).

Time series data cannot always be estimated using a single smoothing polynomial. Political or other structural changes may cause unexpected changes at particular points, for which estimation via a simple polynomial will be insufficient (Marsh, 1987). Spline regression models serve the purpose of including these structural changes into the analysis and so providing for the continuity of the time series. The spline function thus appears to be an appropriate method for properly framing an economic model in cases where structural change is anticipated (Berberoğlu & Berberoğlu, 2011). In some circumstances where the impact of the independent variables on the dependent variable is not linear, a classical linear regression model will be impractical due to weaker estimations, biased estimation results, and violation of the model assumptions. Polynomial and nonlinear spline regression methods are therefore frequently used for the interpretation of curvilinear relationships (Kaps & Lamberson, 2009). Spline regression models earn a distinctive place among regression models thanks to their ability to estimate regression curves with analogous smoothing degrees, even for different locations. Spline regression models are commonly proposed as an alternative to traditional parametric regression approaches (Gregory & Serono, 2008), especially because the latter require linearity assumptions. Spline regression models are more flexible, but their effectiveness is dependent on the number of knots, the location of the knots, and the degree of the polynomial. Identification of the degree of polynomial determines the type of polynomial function suitable for the features of the segment (interval) to ensure best fit to the data (Sarvida & Baguio, 2010).

Equation (1) shows how to estimate the parameters directly from the data (Gnad, 1977). It is possible to verify the spline equation as

$$S^n(x) = \sum_{j=0}^{n} a_j x^j + \sum_{t=1}^{k} d_t (x - \xi_t)_+^n \tag{1}$$

where
  a: the parameter coefficient of independent variables
  x: independent variable
  ξ: knot point
  d: the parameter coefficient of the knot
  n: the degree of spline
and under the restrictions in Equation (2) as follows:

$$(x - \xi_t)_+^n = \begin{cases} 0, & x \le \xi_t \\ x_t - \xi, & x > \xi_t \end{cases} \tag{2}$$

In this sense the knot points, and so ξ_t, are known in advance. The parameters of the spline are a_j and d_t. As the above equations suggest, the spline regression is linear in these parameters.

2.2. Study design, sample and data collection

In the spline literature, the points of change are called knots (Seber & Wild, 2003). Many studies have considered knots when their location is known, looking at two different cases: the case wherein the number of the knots is known, and the case wherein it is unknown (Marsh & Cormier, 2002). In practice, determination of the number and the location of the knots is a crucial issue for fitting the best spline regression model. This study employs spline regression models to fit the distribution of export–import ratios in Turkey between 1923 and 2010. The dependent variable for the study is the distribution of export–import ratios, while the independent variable is time. The study initially determines the knots in order to fit the spline regression models. The study then proposes a methodology based on the coefficient of determination (R^2), for which linear spline regressions are employed, for the determination of the number and the location of the knots. Spline regression literature involves relatively sophisticated and theoretical methods to determine the knots. However, this study intends to propose a simple and conceptive method to determine the knots using parametric splines. The reason for utilising R^2 is to handle the alteration of the coefficient where a structural change is observed between the dependent and the independent variables. Thus, researchers determine the knots with reference to significant changes (increases or decreases) in the coefficient R^2. Practically, this study contains a total of 88 observations for the distributions of export–import ratios between 1923 and 2010. Each year of the study, from 1923 until 2010, represents one observation, where the year 1923 indicates the first year, the year 1924 indicates the second year, and so on. The researchers first fit the linear spline regression models by taking each observation into consideration as a 'candidate' knot.

3. Results

The distribution of export/import coverage ratios in Turkey between 1923 and 2012 shows a nonlinear relationship with structural changes. These structural changes are often effected by regional wars, natural disasters, economic, social and political crises, internal and external shocks, and changes in economic policies. In this respect, semiparametric or nonparametric models are frequently used rather parametric models. This study follows spline regression models which are considered as one the useful semiparametric regression models. The study thus fits a linear regression model with a single knot by adopting the second observation as the knot of the distribution and calculates R^2. Likewise, the study fits a linear regression model with a single knot by adopting the third observation as the knot of the distribution and calculates R^2. The procedure involves six main steps and in conclusion six knots are determined based on R^2 using linear spline regression models, as shown in Figure 1.

The number and the location of the knots so determined are presented in Figure 2. The knots which are determined through the method based on R^2 represent the years of 1933 (11th observation), 1946 (24th observation), 1965 (43rd observation), 1975 (53th
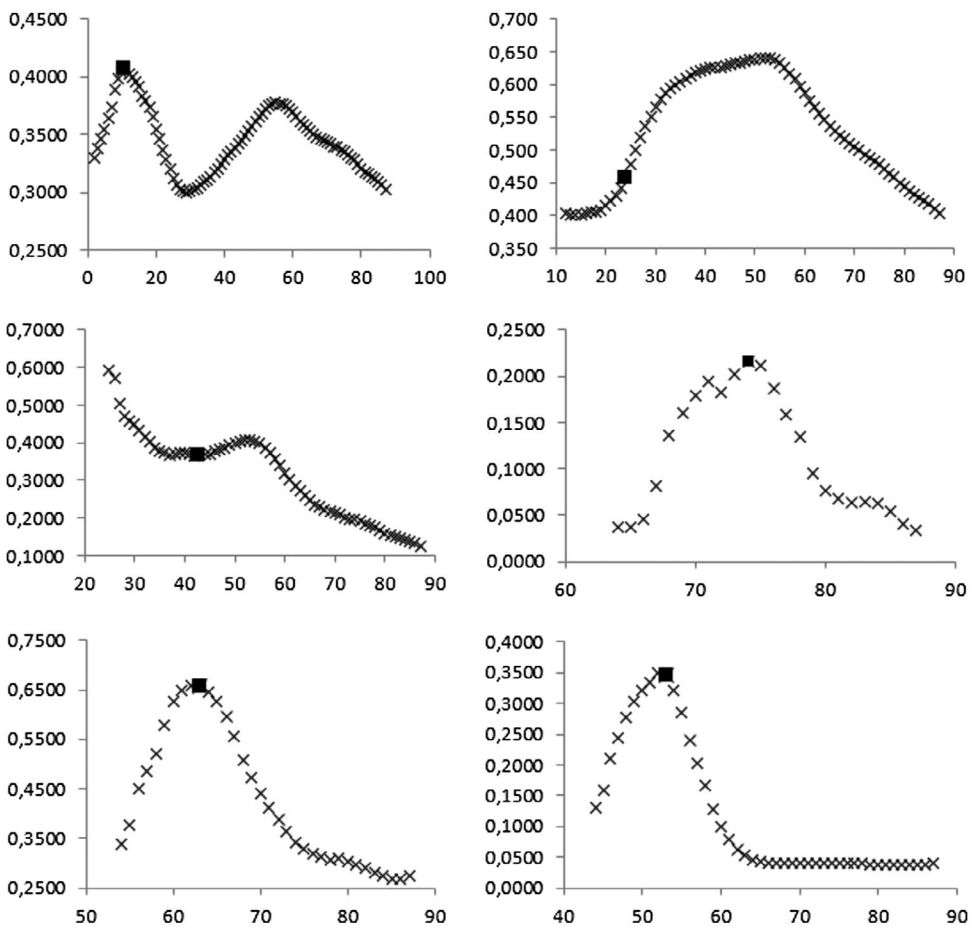

Figure 1. The distribution of R^2 values after each step. Source: Authors' findings.
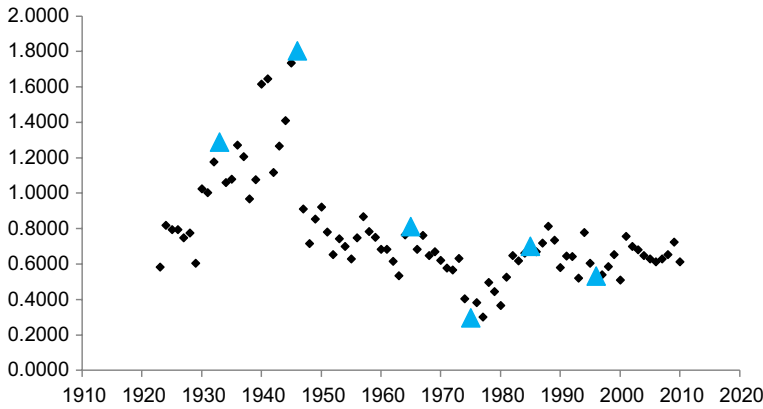
Figure 2. The number and the location of the knots being determined. Source: Authors' findings.
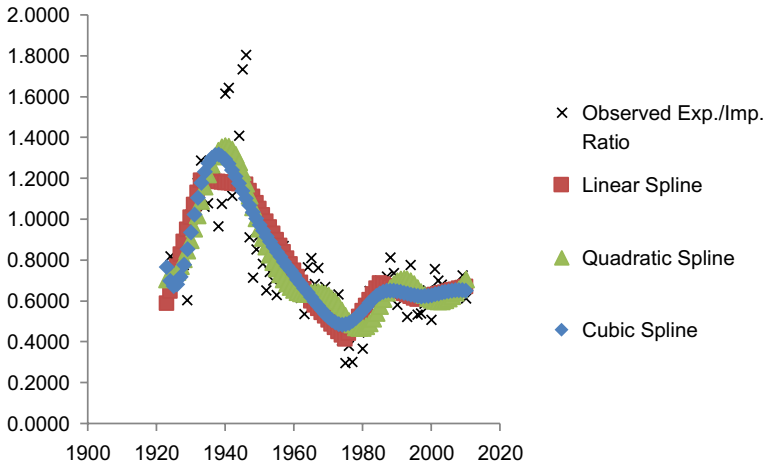
Figure 3. The distributions of estimated and observed export–import ratios using linear, quadratic and cubic spline regression models. Source: Authors' findings.

observation), 1985 (63rd observation), and 1996 (74th observation). The distribution in Figure 2 thus involves seven segments.

Figure 3 summarises the distribution of estimated export–import ratios for linear, quadratic, and cubic spline regression models. As shown in Figure 3 the quadratic spline regression model is the best fitted model with respect to the distributions of estimated export–import ratios. This study also fits polynomial regression models such as simple linear, quadratic, and cubic regression models, by way of a comparison with the spline regression models being fitted.

This study fits polynomial regression models such as the simple linear, quadratic, and cubic regressions in order to maintain the comparisons between spline regression models in Table 1. The reference studies usually estimate distinct models involving a different number of dependent variables and choose the model that is most satisfied with respect to several criteria as the most appropriate model for their analyses (Tarı, 1999).

Table 1. Linear, quadratic, and cubic spline regression model outputs.

Coefficients	Linear Spline Regression			Quadratic Spline Regression			Cubic Spline Regression		
	Variables	Coefficients (Std Err)	Partial t	Variables	Coefficients (Std Err)	Partial t	Variables	Coefficients (Std Err)	Partial t
a_0	Constant	3.2127* (0.509)	6.31	Constant	7.783*(3.035)	2.56	Constant	−46.99*(17.25)	−2.72
b_0	X	0.030184* (0.006788)	4.45	X	0.162***(0.08542)	1.9	X	−2.0784*(0.7522)	−2.76
b_1	(X-1933)	−0.030973*(0.009757)	−3.17	X^2	0.0009271(0.0005925)	1.56	X^2	−0.02937*(0.01082)	−2.71
b_2	$(X-1946)^2$	−0.014245**(0.005961)	−2.39	$(X-1933)^2$	−0.0022534*(0.0007586)	−2.97	X^3	−0.00013554*(0.0000514)	−2.64
b_3	$(X-1965)^2$	0.005722(0.007222)	0.79	$(X-1946)^2$	0.0017761*(0.000297)	5.98	$(X-1933)^3$	0.00016552*(0.00005998)	2.76
b_4	$(X-1975)^2$	0.02308**(0.01008)	2.29	$(X-1965)^2$	−0.0008791***(0.0003551)	−2.48	$(X-1946)^3$	−0.00003207***(0.00001413)	−2.27
b_5	$(X-1985)^2$	−0.017455***(0.009821)	−1.78	$(X-1975)^2$	0.0012566***(0.0005498)	2.29	$(X-1965)^3$	0.00001366(0.00001511)	0.9
b_6	$(X-1996)^2$	0.005941(0.008642)	0.69	$(X-1985)^2$	−0.0015021***(0.0005755)	−2.61	$(X-1975)^3$	−0.00003116(0.0002491)	−1.25
b_7	-	-	-	$(X-1996)^2$	0.0011138***(0.0005929)	1.88	$(X-1985)^3$	0.00003077(0.00002914)	1.06
b_8	-	-	-	-	-	-	$(X-1996)^3$	−0.00001706(0.00003936)	−0.43
Significance		$F_L = 22.17$ $p=0.000$			$F_Q = 26.31$ $p=0.000$			$F_C = 18.98$ $p=0.000$	

* > 99% level of significance.
** > 95% level of significance.
*** > 90% level of significance.
Source: Authors' findings.

Table 2. Model selection criteria.

Model Selection Criteria	Abbreviation
Coefficient of the Determination	R^2
Adjusted R^2	$\bar{R}^2$
Akaike Information Criterion	AIC
Schwarz Information Criterion	SIC
PRESS Value	PRESS
R^2_{pred} Value	R^2_{pred}
Standard Error of the Model	S
Mean Square Error	MSE
The Square Root of Mean Square Error	RMSE
Percentage of the Square Root Of Mean Square Error	%RMSE
Mean Absolute Error	MAE
Percentage of Mean Absolute Error	MAPE
Rational Error	RE

Source: Authors' findings.

Table 3-a. Comparison of the models.

Models/Model Criteria	R^2	$\bar{R}^2$	AIC	SIC	PRESS	R^2_{pred}	S
Linear Spline Regression	0.6658	0.6366	−0.5132	−0.2880	3.0483	60.3800	0.1793
Quadratic Spline Regression	**0.7271**	**0.6995**	**−0.6930**	**−0.4396**	**2.5373**	**67.0200**	**0.1630**
Cubic Spline Regression	0.6865	0.6504	−0.5317	−0.2502	3.1180	59.4800	0.1759
Linear Regression	0.3001	0.2919	0.0898	0.1461	5.6405	26.7000	0.2503
Quadratic Regression	0.3164	0.3003	0.0889	0.1734	5.6449	26.6400	0.2488
Cubic Regression	0.4758	0.4570	−0.1538	−0.0412	4.4119	42.6600	0.2191

Source: Authors' findings.

Table 3-b. Comparison of the models.

Models/ Model Criteria	MSE	RMSE	%RMSE	MAE	MAPE	RE
Linear Spline Regression	0.0321	0.1793	0.2285	0.1208	15.6207	3.5219
Quadratic Spline Regression	**0.0266**	**0.1630**	**0.2078**	**0.1161**	**15.5115**	**3.4077**
Cubic Spline Regression	0.0309	0.1758	0.2241	0.1198	15.8322	3.6915
Linear Regression	0.0626	0.2502	0.3189	0.1779	24.8762	8.8757
Quadratic Regression	0.0619	0.2488	0.3171	0.1659	22.6838	8.4541
Cubic Regression	0.0480	0.2191	0.2792	0.1611	21.8969	6.1340

Source: Authors' findings.

The performance of the models relates to the proximity of the observed and estimated values being tested (Aydin, 2008). The study takes the following selection criteria in Table 2 into consideration to choose the more efficient model through polynomial regression models and the smoothest spline regression models. In Table 2, observing higher values for the coefficient of the determination, adjusted R^2 and PRESS R^2, and lower values for the rest of the selection criteria were expected. Table 3-a and Table 3-b present the results of the model comparison criteria after the required calculations.

As Table 3-a and Table 3-b suggest, spline regression models have more satisfactory results than the polynomial regression models. In addition, the quadratic spline regression model is selected as the most explanatory model among the smooth spline regression models of the distributions of the export–import ratios. Thus, the quadratic spline regression model is adopted as the most effective model.

4. Conclusion

This study proposes a method for studying the distributions of export–import ratios, wherein linear spline regressions are employed on the basis of the coefficient R^2 (see Appendix 1) to determine the number and the location of the knots, which are not known in advance. The suggested method identifies the six knots of the distribution as the years 1933, 1946, 1965, 1975, 1985, and 1996. The fitting of the linear, quadratic, and cubic spline regression models follows the determination of the knots. The results exhibit the following knots as statistically significant: 1933, 1946, 1975, and 1985 for the linear spline regression model; 1933, 1946, 1965, 1975, 1985, and 1996 (at 0.10 significance level) for the quadratic spline regression model; and 1933 and 1946 for the cubic spline models. The knots determined by this analysis should be interpreted from an economic perspective. The Great Depression negatively affected Turkish exports between 1929 and 1932. For this reason, exports tended to decrease until 1933; however, an increasing trend in exports is observed between 1933 and 1938. The milestone year in Turkish export–import ratios was 1933, when both exports and imports began to increase. In 1933, the export–import ratio reached a peak (128.8%), and this was determined as the first knot of this study.

When import commodities relatively exceed export commodities in a country, this may lead to insufficient intermediate, investment or technological and human goods. Therefore, increasing of exports by importing these type of goods may contribute to an export-led economic growth. In this circumstance, both export increase/decrease and import increase/decrease may occur. As the industrial sector of Turkey is substantially dependent on imported intermediate and investment goods, potential increases on internal and external demand may induce increasing current deficits. Particularly, along with outward and export-led economic growth policies after the 1980s, the number of exports and imports showed similarity. On the other hand, during the early years of 1990, foreign trade instability has emerged. Namely, export/import coverage ratio in 1990 decreased by 21% with respect to previous year. There was no significant change on this ratio until 1994, where export/import coverage ratio was 77.8% when import demand decreased with the effect of financial crisis. The export/import coverage ratio tended to decrease until the 2001 financial crisis of Turkey when real exchange rate increased, import demand decreased and the export/import coverage ratio was 75.7%. In later years, the export/import coverage ratio continued to decrease along with relatively increasing imports in comparison with exports. The export/import coverage ratio was generally under 70% considering the excessive appreciation of the Turkish lira, rapid economic growth, and the increase of energy prices such as oil. Consequently, the export/import coverage ratio in Turkey was generally effected by monetary, fiscal, interest and foreign exchange policies, real exchange rates, and national income level.

During the Second World War, the increasing demand for agricultural products simultaneously increased the prices and the volume of Turkish exports, while the volume of imports narrowed. Moreover, exchange rate policies caused excessive appreciation of Turkish lira and led to devaluation 1946. Export–import ratios reached a peak of 180.5% in 1946, which was identified as the second knot of the study. The export–import ratios reached another peak between 1958 and 1987, attaining 81% in 1965, which was determined as the third knot of this study. In contrast, export–import ratios reached a low of 29.6% in 1975 due to the decrease in exports and an increase in imports. 1975 was the fourth knot determined. There was no significant economic change in Turkey until 1985, which was the fifth knot.

The second milestone year for the Turkish economy was 1996, when Turkey entered into a customs union with the European Union and a new export regime was enacted. Export–import ratios reached 53.2% in 1996, decreasing with respect to previous years. This year was the final knot determined. In conclusion, the proposed knots in this study were statistically significant for the quadratic spline regression model. These knots were definitely significant for the Turkish economy with the exception of 1985 (the fifth knot). This study suggests that the quadratic spline regression model provides the best explanation of the data and the underlying structural changes. This study has various limitations. The study only employed three distinctive spline regression models with restricted data in a certain time period. More comprehensive further research using spline regression models may be carried out for other developing countries that enables a benchmarking of knots being determined and a comparison of estimation results. Further studies may also enable a comparison between semiparametric regression models and standard time series data analyses such as structural break tests to examine which model fits well.

Disclosure statement

No potential conflict of interest was reported by the authors.

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Appendix 1. Export, Import and the Export–Import Ratios in Turkey, 1923–2010.

Year	Export (000 $)	Chng. (%)	Import (000 $)	Chng. (%)	Exp./Imp. Ratio (%)	Chng. (%)
1923	50.790		86.872		58.5	
1924	82.435	62.3	100.462	15.6	82.1	40.3
1925	102.700	24.6	128.953	28.4	79.6	-2.9
1926	96.437	-6.1	121.411	-5.8	79.4	-0.3
1927	80.749	-16.3	107.752	-11.3	74.9	-5.7
1928	88.278	9.3	113.710	5.5	77.6	3.6
1929	74.827	-15.2	123.558	8.7	60.6	-22.0
1930	71.380	-4.6	69.540	-43.7	102.6	69.5
1931	60.226	-15.6	59.935	-13.8	100.5	-2.1
1932	47.972	-20.3	40.718	-32.1	117.8	17.2
1933	58.065	21.0	45.091	10.7	128.8	9.3
1934	73.007	25.7	68.761	52.5	106.2	-17.5
1935	76.232	4.4	70.635	2.7	107.9	1.6
1936	93.670	22.9	73.619	4.2	127.2	17.9
1937	109.225	16.6	90.540	23.0	120.6	-5.2
1938	115.019	5.3	118.899	31.3	96.7	-19.8
1939	99.647	-13.4	92.498	-22.2	107.7	11.4
1940	80.904	-18.8	50.035	-45.9	161.7	50.1
1941	91.056	12.5	55.349	10.6	164.5	1.7
1942	126.115	38.5	112.879	103.9	111.7	-32.1
1943	196.734	56.0	155.340	37.6	126.6	13.4
1944	177.952	-9.5	126.230	-18.7	141	11.3
1945	168.264	-5.4	96.969	-23.2	173.5	23.1
1946	214.580	27.5	118.889	22.6	180.5	4.0
1947	223.301	4.1	244.644	105.8	91.3	-49.4
1948	196.799	-11.9	275.053	12.4	71.5	-21.6
1949	247.825	25.9	290.220	5.5	85.4	19.3
1950	263.424	6.3	285.664	-1.6	92.2	8.0
1951	314.082	19.2	402.086	40.8	78.1	-15.3
1952	362.914	15.5	555.920	38.3	65.3	-16.4
1953	396.061	9.1	532.533	-4.2	74.4	13.9
1954	334.924	-15.4	478.359	-10.2	70	-5.9
1955	313.346	-6.4	497.637	4.0	63	-10.1
1956	304.990	-2.7	407.340	-18.1	74.9	18.9
1957	345.217	13.2	397.125	-2.5	86.9	16.1
1958	247.271	-28.4	315.098	-20.7	78.5	-9.7
1959	353.799	43.1	469.982	49.2	75.3	-4.1
1960	320.731	-9.3	468.186	-0.4	68.5	-9.0
1961	346.740	8.1	507.205	8.3	68.4	-0.2
1962	381.197	9.9	619.447	22.1	61.5	-10.0
1963	368.087	-3.4	687.616	11.0	53.5	-13.0
1964	410.771	11.6	537.229	-21.9	76.5	42.8
1965	463.738	12.9	571.953	6.5	81.1	6.0
1966	490.508	5.8	718.269	25.6	68.3	-15.8
1967	522.334	6.5	684.669	-4.7	76.3	11.7
1968	496.419	-5.0	763.659	11.5	65	-14.8
1969	536.834	8.1	801.236	4.9	67	3.1
1970	588.476	9.6	947.604	18.3	62.1	-7.3
1971	676.602	15.0	1,170.840	23.6	57.8	-6.9
1972	884.969	30.8	1,562.550	33.5	56.6	-2.0
1973	1,317.083	48.8	2,086.216	33.5	63.1	11.5
1974	1,532.182	16.3	3,777.501	81.1	40.6	-35.8
1975	1,401.075	-8.6	4,738.558	25.4	29.6	-27.1
1976	1,960.214	39.9	5,128.647	8.2	38.2	29.3
1977	1,753.026	-10.6	5,796.278	13.0	30.2	-20.9
1978	2,288.163	30.5	4,599.025	-20.7	49.8	64.5
1979	2,261.195	-1.2	5,069.432	10.2	44.6	-10.3
1980	2,910.122	28.7	7,909.364	56.0	36.8	-17.5
1981	4,702.934	61.6	8,933.374	12.9	52.6	43.1
1982	5,745.973	22.2	8,842.665	-1.0	65	23.4
1983	5,727.834	-0.3	9,235.002	4.4	62	-4.6
1984	7,133.604	24.5	10,757.032	16.5	66.3	6.9
1985	7,958.010	11.6	11,343.376	5.5	70.2	5.8
1986	7,456.726	-6.3	11,104.771	-2.1	67.1	-4.3
1987	10,190.049	36.7	14,157.807	27.5	72	7.2
1988	11,662.024	14.4	14,335.398	1.3	81.4	13.0
1989	11,624.692	-0.3	15,792.143	10.2	73.6	-9.5
1990	12,959.288	11.5	22,302.126	41.2	58.1	-21.1
1991	13,593.462	4.9	21,047.014	-5.6	64.6	11.1
1992	14,714.629	8.2	22,871.055	8.7	64.3	-0.4
1993	15,345.067	4.3	29,428.370	28.7	52.1	-19.0
1994	18,105.872	18.0	23,270.019	-20.9	77.8	49.2
1995	21,637.041	19.5	35,709.011	53.5	60.6	-22.1
1996	23,224.465	7.3	43,626.642	22.2	53.2	-12.1
1997	26,261.072	13.1	48,558.721	11.3	54.1	1.6
1998	26,973.952	2.7	45,921.392	-5.4	58.7	8.6
1999	26,587.225	-1.4	40,671.272	-11.4	65.4	11.3
2000	27,774.906	4.5	54,502.821	34.0	51	-22.0
2001	31,334.216	12.8	41,399.083	-24.0	75.7	48.5
2002	36,059.089	15.1	51,553.797	24.5	69.9	-7.6
2003	47,252.836	31.0	69,339.692	34.5	68.1	-2.6
2004	63,167.153	33.7	97,539.766	40.7	64.8	-5.0
2005	73,476.408	16.3	116,774.151	19.7	62.9	-2.8
2006	85,534.676	16.4	139,576.174	19.5	61.3	-2.6
2007	107,271.750	25.4	170,062.715	21.8	63.1	2.9
2008	132,027.196	23.1	201,963.574	18.8	65.4	3.6
2009	102,142.613	-22.6	140,928.421	-30.2	72.5	10.9
2010	113,883.219	11.5	185,544.332	31.7	61.4	-15.3

*Chng.: Percentage change compared to the previous year.
Source: Turkish Statistical Institute.