

Nonlinearity of Turkish Credit Default Swap Spreads

Türk Kredi Temerrüt Takası Primlerindeki Doğrusal Olmayan Yapı

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Abstract: In this paper we analyze the stationarity of Turkish credit default swap (CDS) spreads between 10:2000-08:2017 which is an important indicator for researchers and practitioners. For our data, although the most widely used linear unit root test namely augmented Dickey Fuller (ADF) test fails to reject the presence unit root, non-linear tests of Kapatenios, Snell and Shin (KSS) and Sollis claim stationarity with a smooth transition. Moreover, we detect asymmetry for the encountered smooth transition. Thus we encourage researchers to apply KSS and Sollis test along with ADF test in order to understand the driving processes better which will strengthen the predictability and modeling issues of CDS spreads.

Keywords: Credit Default Swap Spread, Unit root, Smooth Transition, Nonlinearity

Öz: Bu çalışmada araştırmacı ve yatırımcılar için önemli gösterge niteliği taşıyan durağanlık kavramı Türk Kredi Temerrüt Takası (KTT) primleri özelinde incelenmiştir. Verimiz için her ne kadar en çok kullanılan doğrusal birim kök testi olan Dickey Fuller (ADF) birim kökün varlığının reddedemeyen, doğrusal olmayan Kapatenios, Snell ve Shin (KSS) ve Sollis testleri yumuşak geçişli bir durağanlık saptamışlardır. Ayrıca, bu yumuşak geçişin asimetrik bir yapıda olduğu bulgularımız arasındadır. KTT primlerinin dinamiklerini anlama öngörülebilirlik ve modellemeyi güçlendireceğinden araştırmacılara ADF testi beraberinde KSS ve Sollis testlerini uygulamalarını da önermekteyiz.

Anahtar Sözcükler: Kredi Temerrüt Takası Primi, Birim Kök, Yumuşak Geçiş, Doğrusal Olmayan Yapı

1. Introduction

Credit default swap (CDS) is a financial instrument which enables investors to trade and hedge credit risk bearing assets at a certain cost given by its spread. So, CDS is actually a financial derivative where the underlying asset is a debt instrument such as credits and bonds which allows the transfer of credit exposure of fixed income products among parties. CDS spread magnitude is an indication of the default probability. CDS contracts can both be written on corporate and government bonds. In that regard, it conveys an idea regarding the credibility of a country in a certain manner.

CDSs have attracted considerable attention in the finance world and experienced a vast growth in the new millennium. After the 2008 crisis following the bankruptcy of Lehman Brothers, the importance of the credit risk of sovereigns has increased substantially and CDS spreads have become a major indicator for assessing the health of the economy and the country risk. Hence the existence of predictable thus stationary paths for CDS spreads is an interesting research area which is important for asset pricing and credit portfolio management. Moreover, as Avino and Nneji (2014) assert, although there is a substantial literature regarding the stationarity of equity, bond and foreign exchange markets, the stationarity of CDS spreads is quite understudied.

When the question is the stationarity of a time series, unit root tests immediately come to surface. Traditionally, augmented Dickey and Fuller (1979, 1981) (ADF) test which is based on a linear framework, is the most widely used one. Despite its easiness, ADF test sometimes detects unit root when the data is stationary, but displays a smooth transition. Kapatenios, Shin and Snell (2003) (KSS) offers a very intuitive way of deriving the asymptotic distribution of the null hypothesis with the presence of an exponential smooth transition autoregressive (ESTAR) function via first order Taylor approximation. Sollis (2009), on the other hand, examined the cases of asymmetry in the transition function and which is an extension of KSS test.

Despite of its overriding importance and attraction, the empirical research regarding the stationarity of CDS spreads is scarce. Since the existing research concentrates mainly on determinants of CDS spreads and their relation with some other macroeconomic variables (with causality or co-integration tests), we could only be able to find limited number of studies for stationarity issues. Aktug, Vasconcellos and Bae (2012) and Kargı (2014) applied ADF test where linear unit root tests are applied to certain sovereign CDS spreads before co-integration and causality tests. Huang and Hu (2012) employed smooth transition autoregressive (STAR) models to characterize the regime switching behavior of 28 US corporate CDS series from January 2007 through October 2009 and found clear evidence for transitions between low-price and high-price regimes.

The rest of the study is as follows. In section 2 we summarize ADF, KSS and Sollis unit root tests together with their critical values. Section 3 is devoted to stationarity and interpretation of Turkish CDS spreads for 10:2000-08:2017. Finally, Section 4 concludes.

2. ADF, KSS and Sollis Unit Root Tests

Functional central limit theorem (FCLT) is essential for ADF test statistics. Theorem 1 is by Donsker (1951, 1952):

Theorem 1: Take independent and identically distributed variables ϵ_t with a zero mean and a variance $\sigma^2 < \infty$. Consider the following partial sum $S_T(r) = \sum_{t=1}^{\lfloor rT \rfloor} \epsilon_t$ where $r \in [0, 1]$ and $\lfloor \cdot \rfloor$ denotes the integer part. Now the scaled version of the partial sum converges in distribution to Brownian motion that is

$$Z_T(r) = S_T(r)/\sigma\sqrt{T} \xrightarrow{d} B(r) \tag{1}$$

Equations (2) and (3) are essential for the determination of ADF test statistics

$$T^{-1} \sum_{t=1}^T y_{t-1} \epsilon_t \xrightarrow{d} \int_0^1 W(r) dW(r) = \frac{1}{2} \sigma^2 [B(1)^2 - 1] \tag{2}$$

$$T^{-1} \sum_{t=1}^T y_{t-1}^2 \epsilon_t \xrightarrow{d} \int_0^1 W(r)^2 dr = \sigma^2 \int_0^1 B(r)^2 dr \tag{3}$$

Through consideration of an AR (1) process, after some calculations the ADF test statistics can be computed as:

$$F(\hat{\delta}) = \frac{\int_0^1 B(r) dB(r)}{\int_0^1 B(r)^2 dr} = \left(\frac{1}{2}\right) \frac{[B(1)^2 - 1]}{\int_0^1 B(r)^2 dr} \tag{4}$$

For demeaned and de trended Brownian motions we replace $B(r)$ with

$$B(r)_\mu = B(r) - \int_0^1 B(s) ds \tag{5}$$

$$B(r)_\beta = B(r) - (6r - 4) \int_0^1 B(s) ds - (12r - 6) \int_0^1 sB(s) ds \tag{6}$$

(for detailed proofs and derivations see Hamilton, 1994 and Patterson, 2010).

The asymptotic critical values of ADF test are given in Table 1

Table 1. Asymptotic critical values of ADF test

Significance	No Term	Constant	Trend
1%	-2.58	-3.43	-3.96
5%	-1.95	-2.86	-3.41
10%	-1.61	-2.57	-3.12

KSS test considers the unit root null $H_0: \theta = 0$ vs. the nonlinear alternative $H_1: \theta > 0$ for the ESTAR framework as

$$\Delta y_t = \gamma y_{t-1} \{1 - \exp(-\theta y_{t-1}^2)\} + \epsilon_t, \quad \epsilon_t \sim N(0, \sigma^2) \tag{7}$$

The particular choice of $\{1 - \exp(-\theta y_{t-1}^2)\}$ comes from the fact that its first order Taylor approximation is a polynomial yielding an analytically tractable OLS test regression coefficient under the null hypothesis as

$$\Delta y_t = \delta y_{t-1}^3 + \text{error term} \tag{8}$$

The distribution under the null hypothesis $\delta = 0$ is stated in (9)

$$t \Rightarrow \frac{\frac{1}{4}W(1)^4 - \frac{3}{2}\int_0^1 W(r)^2 dr}{\sqrt{\int_0^1 W(r)^6 dr}} \tag{9}$$

Sollis (2009) KSS explored the possible asymmetry in the transition function and developed a unit root test stated by Equations (10), (11) and (12)

$$\Delta y_t = G_t(\gamma_1, y_{t-1})\{S_t(\gamma_2, y_{t-1})\rho_1 + (1 - S_t(\gamma_2, y_{t-1}))\rho_2\}y_{t-1} + \varepsilon_t \tag{10}$$

$$G_t(\gamma_1, y_{t-1}) = 1 - \exp(-\gamma_1(y_{t-1}^2)), \quad \gamma_1 \geq 0 \tag{11}$$

$$S_t(\gamma_2, y_{t-1}) = [1 + \exp(-\gamma_2 y_{t-1})]^{-1}, \quad \gamma_2 \geq 0 \tag{12}$$

As done in the KSS test, first order Taylor expansion is applied to the function given in Equation (11). Moreover, first order Taylor expansion is applied to Equation (12) as well yielding the auxiliary relation:

$$\Delta y_t = \Phi_1 y_{t-1}^3 + \Phi_2 y_{t-1}^4 + \eta_t \tag{13}$$

For this case the null hypothesis of Equation (10) denoted by $H_0: \gamma_1 = 0$ is transformed into

$$H_0: \Phi_1 = \Phi_2 = 0 \tag{14}$$

Since we wish to test whether two variables are simultaneously equal to zero or not, instead of *t*-statistics used in ADF or KSS tests, one should apply *F*-statistics. In that regard the asymptotic distribution of Equation (14) becomes

$$F_{AE} \xrightarrow{d} h^T Q^{-1} h / 2\sigma^2 \tag{15}$$

$$h^T = \left[\sigma^4 \int_0^1 W(r)^3 dW(r) \quad \sigma^5 \int_0^1 W(r)^4 dW(r) \right] \tag{16}$$

$$Q = \begin{bmatrix} \sigma^6 \int_0^1 W(r)^6 dr & \sigma^7 \int_0^1 W(r)^7 dr \\ \sigma^7 \int_0^1 W(r)^7 dr & \sigma^8 \int_0^1 W(r)^8 dr \end{bmatrix} \tag{17}$$

The derivation is similar to KSS test; however, a bit lengthy. Readers can follow the detailed proof from Sollis (2009). The asymptotic distribution given by Equations (15), (16) and (17) is for “no term” case. For cases “constant” and “trend” $W(r)$ should be replaced with the equalities in Equation (4) and (5). The critical values for Sollis test is given in Table 3.

Table 3: Critical values of Sollis test

# of Observations	No Term			Constant			Trend		
	10%	5%	1%	10%	5%	1%	10%	5%	1%
50	3.577	4.464	6.781	4.009	4.886	6.891	5.415	6.546	8.799
100	3.527	4.365	6.272	4.157	4.954	6.883	5.460	6.463	8.531
200	3.496	4.297	6.066	4.173	4.971	6.806	5.590	6.597	8.954
Asymptotic	1.837	2.505	4.241	3.725	4.557	6.236	5.372	6.292	8.344

3. Data and Results

Our data is comprised of daily 5-year maturity Turkish CDS spreads for 10:2000-08:2017 extracted from Bloomberg which is depicted in Figure 1. We took the longest available period. High oscillations at the beginning arose from a series of events which can be summarized as follows:

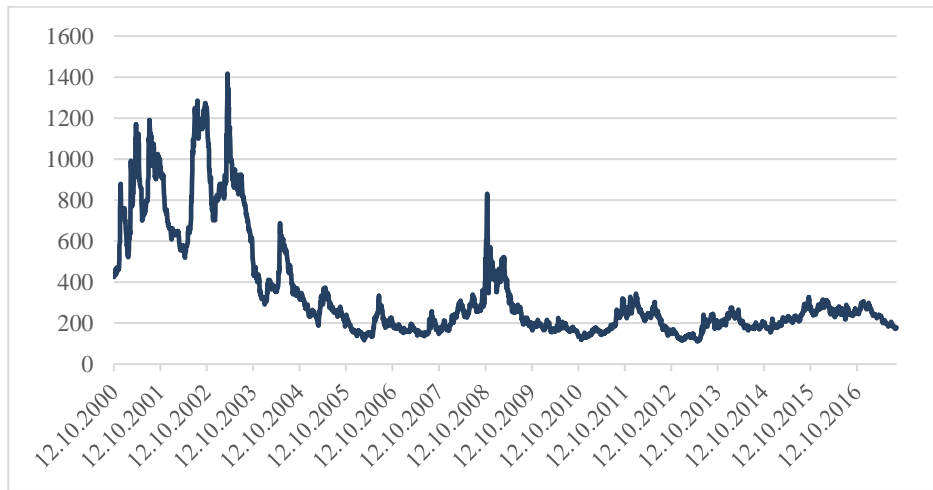


Figure 1. Daily Turkish CDS spreads for 10:2000-08:2017

Source: Bloomberg

In November 2000, banks start closing their interbank credit lines to vulnerable Turkish banks, after concerns about health of the banking sector have increased sharply. This is followed by substantial withdrawals from domestic and foreign investors. On December 2000 for Demirbank, all credit lines are cut by other major banks. This caused a panic situation and severely raised the interest rates. On December 6, Demirbank failed and is taken over by the Savings Deposit Insurance Fund. Turkish stock index plummeted from 14.000 to 9.000 within 2 months.

The turmoil in November is followed by a political crisis in early 2001. On February 21, the prime minister and president had a severe dispute. Again, trust in the sustainability of the stability program vanished. Stock exchange fell by 14% and interbank rates skyrocketed, rising from 50% to 8000%. Meanwhile, foreign exchange reserves again declined rapidly. On February 22, the government allowed lira to float freely. As a result, the Turkish Lira lost about one-third of its value against the dollar (See Ozatay and Sak (2003)). These developments shoot the CDS spreads around 1200 bps. After the mid of 2001 the spreads began to go down and reached a level of 600 at the end of the first quarter of 2002. However, the announcements regarding an early general election and the surprising results of the November 2002 election again caused a pressure and enabled the spreads to test the previously recorded historical highs. After the digestion of the new parliament the spreads fell to 700s at the end of 2002. However, the March 2003 military memorandum crisis again triggered sharp spikes and Turkey CDS spreads made its summit of 1416 bps at the end of March 2003.

Turkey CDS spreads gradually fell to levels around 200 bps within the years and except the 2008 crisis (in which we experience 800s) continued to fluctuate around 200 onwards.

Kunt and Taş (2008) applied ADF test to Turkish CDS spreads for 08:2000-01:2008 period and detect unit root. Our results are similar for the extended period with ADF test. However, KSS test rejects the presence of unit root constant and trend case at 5% and constant case at 10% significance level as shown in Table 4.

Table 4: Unit root test results for ADF and KSS tests

<i>t statistics</i>	<i>No Term</i>	<i>Constant</i>	<i>Trend</i>
<i>ADF Test</i>	-1.5763	-2.2892	-3.0138
<i>KSS Test</i>	-2.7234**	-2.8364*	-3.3864**

*, **, *** denote significance at 10%,5% and 1% respectively

In order to check for asymmetry in the transition function we investigate further and come up with more significant results by employing Sollis test. The results are portrayed in Table 5.

Table 5: Unit root test results for Sollis test

<i>F statistics</i>	<i>No Term</i>	<i>Constant</i>	<i>Trend</i>
<i>Sollis Test</i>	5.0985**	6.7759**	10.1547***

*, **, *** denote significance at 10%,5% and 1% respectively

We deduce that Sollis test captures the presence of an asymmetric smooth transition for no constant and constant case with 5% significance level. However, one should be cautious in interpreting these results in the sense that the *F* statistics

is found to be 5.0985 and 6.7759 respectively and when compared with the critical values presented at Table 2 for 1% significance level, our statistics lies within 200 observations and asymptotic value indicating a possibility of 1% significance level since our number of observations are 8643. Nevertheless, as for no constant term case critical values change drastically when the number of observations increase beyond 200 and changes in a smoother manner for constant case, in order to be on the safe side we attribute a 5% significance level for the presented data. Yet, both KSS and Sollis test claim 5% significance level for no constant and constant cases which gives us room for the presence of an asymmetric smooth transition.

For the trend case, the F statistics is found to be 10.1547 which surpasses all the critical values considerably indicating a 1% significance level while KSS test fails claims 5%. Moreover, the changes in F statistics with respect to an increase in the number of observations is considerably flatter especially for lower significance levels. Consequently, a comparative analysis of the above test results indicates the existence of an asymmetric smooth transition with trend rather than a symmetric one.

4. Conclusion

Due to the growing importance of the predictability and stationarity issues, we analyze the statistical properties of Turkish CDS spreads for 10:2000-08:2017. In our analysis, ADF test fails to reject the presence of unit root whereas KSS test claims a symmetric smooth transition. However, for a thorough analysis we proceed with Sollis test to check for the presence of asymmetry of the encountered smooth transition. As Sollis test results have higher significance levels than KSS test, we deduce that an asymmetric smooth transition is in fact at stage for Turkish CDS spreads.

Overall, our findings lead us to conclude that Turkish CDS spreads are stationary and we encourage researchers to apply KSS and Sollis test along with ADF test in order to understand the driving processes better since it will strengthen the predictability and modeling issues.

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