The Analysis of Structural Changes in the Reserves of the Bank of England

Mehmet ÇETİN*

ABSTRACT

Bank of England, one of the leading examples of modern banking, has been established at the end of the 17th century. Economic and social turmoils and wars that broke up in the first half of the 19th century have led to a serious debate between the Currency School and Banking School regarding the primary function of BoE. The Bank Charter Act dated 1844 has been enacted to eliminate the ongoing instabilities in the British economy. The act was suspended in 1847, 1857, and 1866 because of the developments. In this study, the effects of economic and non-economic developments on the Bank's reserves are investigated using the structural breakpoint tests for the period between 1844 and 1866. To detect the presence of any regime shifts in both series mean and variance, the Bai and Perron and ICSS algorithm procedures were employed. The findings of the study reveal the effects of domestic and foreign military, political and economic developments directly affecting the UK, on the reserves of the Bank.

Key Words: *Bank of England, The Bank Charter Act of 1844, Structural breaks.*

JEL Classification: *N23, E58, E52*

İngiltere Merkez Bankası Rezervlerinde Meydana Gelen Yapısal Değişimlerin Analizi

ÖZ

17. yüzyılın sonunda teşkil edilen Bank of England, modern bankacılığın önde gelen örneklerindendir. 19. yüzyılın ilk yarısında gerçekleşen ekonomik ve toplumsal çalkantılar ve savaşlar, Bankacılık ve Para okulları arasında BoE'nin öncelikli işlevinin ne olduğuna dair ciddi bir tartışma başlatmıştır. 1844 tarihli Bankacılık Yasası İngiliz ekonomisinde süregelen istikrarsızlığı ortadan kaldırmak amacıyla yürürlüğe konulmuştur. Yasa, 1847, 1856 ve 1866 yıllarında yaşanan gelişmelere bağlı olarak askıya alınmıştır. Bu çalışmada ekonomik ve ekonomi dışı gelişmelerin bankanın rezerleri üzerindeki etkileri 1844-1866 dönemi için yapısal kırılma testleri yardımıyla araştırılmıştır. Serilerin ortalamalarında ve varyanslarında meydana gelen rejim değişikliklerinin tespit edilebilmesi amacıyla Bai-Perron testi ve ICSS algoritması kullanılmıştır. Çalışmanın bulguları, İngiltere'yi doğrudan etkileyen iç ve dış askeri, politik ve ekonomik gelişmelerin Bankanın rezervleri üzerindeki etkilerini ortaya koymaktadır

Anahtar Kelimeler: *İngiltere Merkez Bankası, Yapısal Kırılmalar, 1844 Bankacılık Yasası*

JEL Sınıflandırması: *N23, E58, E52*

INTRODUCTION

The history of modern central banks dates back to the 17th century. Despite the differences across time and regions, the primary target of the central banks is to provide monetary and financial stability. The Bank of England (BoE), one of the oldest banks was established in 1694, to provide financial support for the war

* Doç.Dr. Dokuz Eylül Üniversitesi, İktisadi ve İdari Bilimler Fakültesi,İktisat Bölümü. mehmet.cetin@deu.edu.tr, ORCID Bilgisi: 0000-0002-6954-0908

(Makale Gönderim Tarihi: 15.03.2021/ Yayına Kabul Tarihi:09.12.2021)
Doi Number: 10.18657/yonveek.896221
Makale Türü: Araştırma Makalesi

against France (De Kock, 1974: 1-17). It was expected to get a cheap loan and to preserve the financial position of the king owing to the establishment of the Bank (Cook, 2005: 193; Adreades, 1909: 44). The interventions of the BoE were quite critical in terms of the circulation of the short term government debts and broadly the functioning of the money market in the following period (Bordo and Eugene, 1991: 303-316; Antiba and Chamley, 2017: 25).

A continuous panic had dominated the British money markets from the beginning to the second quarter of the 19th century. The reason for this situation was the banks that both issue money and give credit. The expectations related to the failure of credits following every bad harvest and commercial bottlenecks caused deposit owners to rush to the banks and demand gold or BoE banknotes. In the case of the imperfect knowledge about the bank, which was the source of risk, the panic became a lending crisis and then turned out to be a liquidity crisis (Quinn, 2001: 31). The most heated arguments on the British economics took place between the Currency and Banking Schools during the second quarter of the 19th century and, the 1844 Bank Charter Act in which the views of the Currency School outweigh was implemented by Robert Peel, the prime minister of its period (Andreades, 1909: 285).

The economic, political, and social developments of the subsequent period required the active intervention of the BoE and also caused the Bank Charter Act to be questioned frequently. The Great Famine of 1846 following the failure of potato harvest in Ireland in 1845, the commercial crisis of 1847 induced by the railway mania, the Chartist movement which affected the real sector seriously, speculative attacks following the end of the Great Exhibition in 1851, the Crimean war of 1853 and the global crisis after the war, and the Overend-Gurney crisis of 1866 are important developments that affected the policies and balance-sheet of the BoE in the period analyzed.

In this study, the breaks in the reserves of the BoE between 1844 and 1866 are analyzed by the Bai-Perron structural breakpoint test and ICSS (Iterative Cumulative Sum of Squares) algorithm. The time period of the study is determined in accordance with the entry of the Bank Charter Act into force in 1844 and the repeal of the act during the 1866 crisis. The regime breaks are identified using the ICSS method, which can serve as a good starting point of a regime shift analysis since it has fewer parameters to be adjusted compared with the recent methods (Rodionov, 2016: 63-78). The consistency of the breakpoint dates obtained as a result of the analysis with the eco-political developments during the period is investigated. Thus an important period regarding the European banking history is tried to be enlightened. The main factor for the 1844 Act to be chosen as a baseline is that the act was mainly conceived and enacted against the crisis which took place in the British economy. The milestones that caused the Act to be repealed will be determined.

In the following section, applied studies that take place in the literature related to the BoE are set forth. The changes in the functioning of the BoE after the 1844 Bank Charter Act will be stated in the context of the controversies between

the Currency and Banking Schools in the third section. And then, general information was given about the suspension of the Act during the crisis in the period. The econometric analysis and test results related to the breakpoint dates in the reserves will be represented in section four. The last section is a brief conclusion.

I. LITERATURE REVIEW

There is a broad spectrum of researches that takes the Victorian age and the BoE as a base, but the number of studies that move through the reserves of the BoE is quite limited. Anson et al. (2017) is the preeminent study among others owing to the datasets compiled and published from the daily transactional ledger data from the BoE's archive. They tested whether and to what extent the Bank's monetary policies conform with the Bagehot rule. Although the findings of the study vary across the 1847, 1857, and 1866 crises, the Bank's behavior broadly conforms to Bagehot's rule.

The policies followed by the BoE are correlated with the Classical Gold Standard in many of the studies that analyze the pre-WWI period. Accordingly, Dornbusch and Frenkel (1984) evaluates the performance of the BoE during the 1847 Crisis. According to the findings, the Bank had to lower the discount rate and issue bonds to provide confidence at the expense of the destructive results of the financial crises. Additionally, the 1844 Bank Charter Act and the strict rules of the Gold Standard System should be repealed to eliminate the confidence loss.

In a similar manner, Dutton (1984), searches for an answer to whether the BoE followed the regulations of the Classical Gold Standard System. According to the results, the Bank does not react countercyclical to domestic activities or price changes, and the reaction is present even controlling for the effects of reserves on Bank policy.

The exogenous shocks that occur in the Gold Standard System could affect the reserves of the BoE via gold outflows. From this point of view, Jeanne (1995) analyzes the relationships between gold outflow, the changes in interest rate policy, and the changes in the monetary base using Vector Auto Regression method. In this sense, the connections between the external monetary disturbances and British economic developments are revealed in the study. According to the results of the study, the Classical Gold Standard operates differently in times of crisis; in other words, external monetary shocks that cause a moderate outflow of gold can be tolerated by slight changes in the interest rates.

Davutyan and Parke (1995), who brings the Classical Gold Standard System into the focus of their study, analyzes the role of the BoE in the success of the system via dynamic probit econometric method and put forth that there is not a negative relationship between the gold stock and discount rate of the Bank. Although the gold outflow causes a sharp increase in the discount rate of the Bank, an asymmetric reaction occurs in the time of gold inflow and this situation proves the non-existence of any relation between the BoE policies and the success of the Gold Standard System.

Toma (1999) develops a model that puts forth the positive relationship between the reserve requirements of the central banks and the interest payments on reserves. The study adopted cointegration, error correction mechanism, and Granger causality tests and put forwards that the government's financing requirements help to clarify the reserve requirement movements and that interest rates on reserves vary with market loans.

Among the recent studies, Kuttner (2010) emphasizes the resemblances between the policies adopted by the BoE who took the responsibility of acting as the last lending resort and as a central bank following the Bank Charter Act in 1844 and the policies adopted by the FED in 2007/8 crisis. According to the findings, the Bank Charter Act obstructed the Bank to show the necessary reaction in the course of financial panic. Nevertheless, the Bank was successful in maintaining price stability. The most important factor that simplified the FED to determine and control the monetary policy during the crisis was bailouts.

Le Maux (2018) develops a critical approach to the comments related to the periodical interest rate policies of the BoE and to the views that support the 1844 Bank Charter Act to be a critical step for the development process of the central banking in Britain. The study bases on the adherence between the monetary history, history of economic analysis, and the institutional approach to money and banking.

Taking up the related studies comprehensively, the central bank policies seemed to be handled independently of the global economic and political developments. In this context when we make an evaluation over the variation in the literature related with the topic and when we take into account that the London was the world's top financial center and the BoE was the main institution that directs the monetary policies of the United Kingdom that was indisputably unrivaled in the global markets between the period starting with the end of Napoleonic Wars to the long depression started at the beginning of 1870s, the contribution of this study is to associate the changes in reserves as a critical indicator of the balance sheet of the Bank to the internal and external dynamics of the post-1844 period. The study not only makes a doctrinal contribution with the parametric approach it brings to the reserve discussion between the Banking and Currency schools, it also sheds light on an important historical case and period, depending on the actuality of the discussion on the national reserves.

II. HISTORICAL BACKGROUND

The BoE was the main institution that issue banknotes and maintained the convertibility of sterling by keeping sufficient gold in its reserves in the first quarter of the 19th century. One of the main missions of the BoE was to preserve the gold reserves of Britain and this situation created expectations of funding the financial institutions and other banks in the country in the time of crisis as the lender of last resort. Many banks located out of London was also authorized to issue banknotes. But the BoE was responsible for the larger part of the currency. The position of the bank got highly difficult by the implementation of the Act of Usury dated to 1833 which limited the maximum lending rate to %5 to all debt transactions in 1839. The

constant fall off in the convertibility of sterling to gold in 1825 and the extreme fall off in the gold reserves to the level of crisis brought forward the support of Bank of France to the BoE to maintain its integrity (Eltis, 2001: 5-6). This situation and similarly the crises of 1825, 1836 and 1839 which occurred between the period of 1821 and 1844 in which Britain turned back to the metallic currency standard, caused a long-lasting discussion between the Currency School and the Banking School on the question of what the main function of the BoE should be (Humphrey and Keleher,1984: 290).

Although there is not a consensus between the members of both schools, according to the members of the Currency School the amount of money in the circulation will react automatically and in a short time to the gold flows in and out in the systems based on the metallic money. However, in the mixed systems which include convertible paper money, a regulation intended for the issue of paper money is required to provide the auto-mechanism to recover its absence. In the absence of such regulations the persistence of convertibility can not be guaranteed in the situation of possible monetary expansion via an excess issue of paper money and crisis can arise resulting from the fluctuations in the currency. In fact, the provision of convertibility is not sufficient to prevent the short term crisis separately. The BoE and rural banks can issue excess banknotes even in the case of convertibility. In this manner, a specific mechanism that controls the issue of banknotes is required to overcome the financial drawbacks and to provide the permanency of convertibility. This control mechanism turned into an obligatory rule that entitles monopolistic privileges to the BoE about the issue of banknotes and links the banknote issue to the gold flows (Humphrey and Keleher,1984: 291; Viner, 1955: 220-221).

The Banking School has denied all the assumptions of the Currency School. According to the Banking School, a certain amount of gold is held in the reserves of the BoE and other banks rather than being in the circulation in the pure metallic currency systems. A change in the amount of gold reserves will not affect the price level and relatedly a change in the gold stocks of the country will not cause fluctuations in the currency. Consequently, the Banking School did not put forward a new program alternative to the current regulations about the control over the currency. Because the banknotes in the circulation are controlled sufficiently via the competition between the banks (Viner, 1955: 222-223).

The discrimination between the issue of banknote and the financial mediation functions caused a problem related to the determination of the level of the money supply. At this point, there is a definite difference between the views of the Banking School and the Currency School. Hereof while the members of the Currency School follow a prescriptive way (gold standard – Ricardo, k-percent rule – Friedman, price level rule – Irving Fisher), the members of the Banking School are in the opinion that any rule to be implemented related with the conditions will lose its force because of the astatic structure of the financial system. According to the Currency School, the issue of banknotes done by the private sector is an inappropriate seigniorage transfer from the public sector to the private sector and

this thought lies behind the views of the Currency School related with the discrimination between the issue and financial mediation functions (Goodhart and Jensen, 2015: 3-4).

The short-term liabilities of the BoE related to the short-term deposits were backed one-third by gold and silver specie and the remaining two-thirds by interest-bearing assets following the Palmer Rule adopted by John Horsley Palmer before 1844. A specific link between the Bank's banknote and gold reserves has not been identified. As an intense outflow of gold occurred in the years 1825, 1837, and 1839, the Bank increased the issue of banknotes and sold out its investments to preserve the rule (Eltis, 2001: 8). The Peel government brought into the Bank Charter Act which represents the victory of the Currency School of Ricardo on July 19th, 1844. According to Peel's expression, the purpose of the Act was to hinder the sudden depressions to cause panic and chaos, to forestall the speculative operations which can occur through the abuse of credit given in exchange with bill and maintain the convertibility of currency (De Soto, 2006: 484; Andreades, 1909: 339). In this context, the main basis for the act was the recurrent financial crisis and ongoing instabilities. Especially the banking sector display fragility and the rapid increase in the number of joint-stock companies caused the risk perception to get exacerbated (Arnon, 2010: 187). At the point of implementation, the Currency Theory was applied to the Palmer Rule by the act. According to this, while the Quantity Theory of Money which clarifies the connection between the currency volume, price level, and exchange rates was pursued; the effects of deposits on price and gold flows and the effects of natural reasons like bad harvests on exchange rates were ignored (Horsefield, 1944: 183).

The sterling was taken under preservation by the Act but this preservation was provided not with the flexibility but contrarily with the firm characteristics of ensured by the Act. The split of the BoE into two departments; the banking department and the issue department limited the reserve of the bank in a strict manner (Hughes, 1967: 92). According to the Act, any change in the amount of the banknotes issued by the BoE will be equal to the amount of the change in the precious metal reserves of the issue department. The issue of representative money was limited with 14 million pounds and the issue of supplementary banknotes was limited with the hundred percent of marginal bullion reserves. The issue department will be the sole authority to issue banknotes and the exchange between the gold and banknotes will be done over a fixed rate of one-ounce gold for 3 pounds, 17 shillings, and 10,5 pence (Arnon, 2010: 186; Dornbusch and Frenkel, 1982: 238; Anno Septimo & Octavo, 1844: 331). The issue of new banknotes will be bound up with the amount of gold held in the reserves of the issue department. Thus the legislator aimed to provide price stability and financial stability. The banking department will retain a certain part of the total banknote stocks of the issue department in its reserves and the changes in the liabilities of the banking department in terms of deposits will not depend on the gold reserves. In this way, flexibility will be provided to satisfy the demand for credits (Anson et. al, 2017: 23-24).

Moreover, the banknotes issued by rural banks will not be legal tender. The whole tendency of the 1844 Bank Charter Act was to eliminate the banknotes out of the control of the BoE gradually. If any bank goes bankrupt, it will lose its authorization to issue banknotes. The rural banks can not issue banknotes unless more than six of them come together (Andreades, 1909: 292). Thus the act enabled the BoE to form an efficient monopoly over the issue of new banknotes. It abandoned the responsibilities and measures taken over by the BoE before 1844 and with reference to the monopolistic right to issue banknote is inherent to central banking, give the central bank position to the BoE (Whale, 1944: 109; Anson, et. al, 2017: 23).

In the period of study between 1844 and 1866, the BoE functioned following the principles determined in the 1844 Act and responded to the important economic and political developments via discount rates and relatedly changes in the reserves. According to Eichengreen, central banks that alter discount rates in response to shocks arising in their money markets, operate completely different in periods of crisis, and instead of competing for gold, pool their reserves to improve their ability to avoid convertibility crises in the pre-1914 period (Eichengreen, 1992: 7). Following the repeal of the Usury Law in 1833, the BoE had the authority to exceed the limit of %5 that was in force in the previous period and abled to increase the discount rate over the legal limits in the time of crisis. The 1844 Act brought about a very important change related to the determination of the discount rate. Although the BoE defined a uniform rate for all the bill of exchanges discounted before 1844, minimum rates for the short-term and secured ones and maximum rates for the long-term and low secured ones were defined subsequently (Anson, et. Al, 2017: 37, 39, 50).

The developments affecting the reserves can be originated both externally or internally. The increase in the trading volume, wage payments, etc., can be the reason for the outflow of banknotes from the BoE. While a usual and expected fluctuation (gold outflow related to the domestic operations) did not affect the discount rates, unusual activities, or foreign gold flows altered the case (Andreades, 1909: 326). In this context, one of the most important adversities in the structure of the BoE was its insufficiency of meeting the sudden and excessive demands. Generally speaking, although the Bank Charter Act of 1844 deprived of the BoE to use all facilities it has during the critical periods and could not prevent the crises to occur but owing to the act, the BoE met the crises with much richer reserve of gold when compared with the period before 1844. In the progress of time, the BoE learned how to use its reserves during the crisis via manipulations done over the discount rates. Therefore the act yielded satisfactory results because it did not function as it was designed (Whale, 1944: 111; Marx, 2004: 293; Kindleberger, 1984: 68).

Nevertheless, the main factor affecting the fate of the act was extraordinary reductions in the reserves. The variability in the reserves arose from the fact of gold to be the only legal tender in the United Kingdom. Ultimately the act was suspended partially during the 1847 crisis and suspended temporarily and fringed for the first

time because the reserves of the BoE came to the point of exhaustion during the 1857 crisis which gradually deepened depending on the depressive effects of the Crimean War on economics. Thus crisis management technique worked out in 1847, 1857, and in 1866; it was the BoE suggestion to put an escape hatch into the Act. In principle, the suspension of the act proved to be sufficient to decrease the severity of the crisis exclusively. This was implemented to provide the confidence of British legislation. But in fact, it was the most obvious evidence that shows the weakness of the system (Andreades, 1909: 323, 328, 350; Dornbusch and Frenkel, 1984: 269).

III. DATA SET AND ECONOMETRIC ANALYSIS

In this section, the data analyzed in the study is described initially and then the theoretical information and the application results of the Bai-Perron structural breakpoint test and ICSS algorithm are given.

A. Data Specification

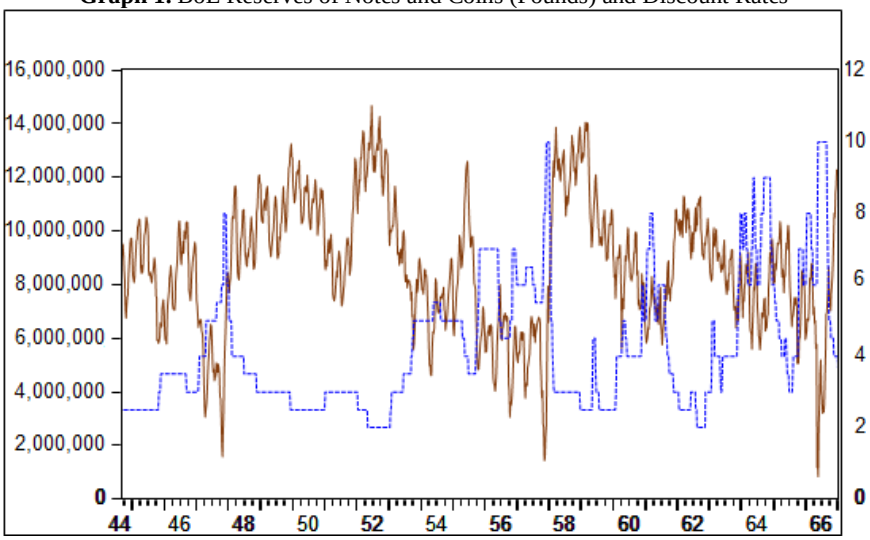
BoE reserve data for the dates 07/09/1844 and 26/12/1866 were used in the analysis carried out in the study. The data is weekly and in logarithmic form. Bai-Perron structural breakpoint test is made using Eviews 10 and ICSS algorithm is made using Excel and Gauss 21. The data set is taken from Huang and Thomas (2016). Descriptive statistics for the data set are presented in the table below.

Table 1. Descriptive Statistics

Sample	07/09/1844 – 29/12/1866
Observations	1165
Mean	15.93462
Median	15.98431
Maximum	16.50337
Minimum	13.66466
Standard Deviation	0.326370
Skewness	-1.636843
Kurtosis	8.826169
Jarque-Berra	2167.932
Probability	0.000000

The visual of the data is given together with the discount rate applied by the bank in the graphic below. According to the statistics given in the Table 1, the data is highly skewed and leptokurtic as the value of kurtosis is bigger than three. We can reject the hypothesis of normal distribution at the 1% level till the probability value of Jarque-Berra is smaller than five percent.

Graph 1. BoE Reserves of Notes and Coins (Pounds) and Discount Rates



As can be seen in the Graph 1, serious decreases in the reserves of the Bank especially during the crisis periods are remarkable. There is a connection between the reserves and the changes in the discount rates which is a tool for the Bank to implement a policy. Actually, a considerable decrease in the amount of money would be experienced because of the people who tend to exchange the banknotes they hold, with the gold in the depression periods following the overheated economic conditions. Relatedly it is proposed that the BoE will attract gold from abroad by increasing the discount rates and will decrease the lending rate to retain its reserves. Thus it is thought that the Act will support both financial stability and price stability (Anson et. Al, 2017: 23). In the following section at first the breakpoints in the mean and the variance of the reserve data will be determined and then the connection of breaks in reserves with regional and global economic and political developments will be demonstrated using the Bai-Perron (2003) breakpoint test and ICSS algorithm.

B. Bai-Perron Structural Breakpoint Test and ICSS Algorithm

Economic variables are affected by many factors and have a trend that shows temporary or permanent changes over time. Permanent changes are called a structural break in the literature (Güriş and Çağlayan, 2000: 695). Testing structural breaks have been an important issue in econometrics, as political and economic factors cause the relationships between economic variables to change over time. Among the breakpoints tests in time series, Bai-Perron Multiple breakpoint tests, which analyze breaks in the mean and ICSS breakpoint test which analyze the breaks in variance are commonly used. Bai-Perron (1998, 2003), is a unit root test, developed based on the estimation of the least-squares method for times when multiple breaks are unknown (Bai and Perron, 1998: 47-78). The most important feature of the Bai-Perron test is that it enables the determination of each breaks consistently by following a special to general method in finding the number of breaks (Esteve and Requena, 2006: 119).

Bai-Perron (1998) describes global optimization procedures for identifying the m multiple breaks that minimize the sums of squared residuals of the regression model. The model used for the Bai-Perron multiple structural breakpoint tests considering m breaks and m+1 regimes is as shown below (Bai and Perron, 1998: 49).

$$y_t = x_t'\beta + z'_t\delta_j + u_t \quad t = T_{j-1} + 1, \ldots\ldots, T_j \quad j = 1, \ldots\ldots m \qquad (1)$$

Here y is the dependent variable, xt and zt are vectors of independent variables with dimensions (px1) and (qx1), and ut is the error term. Tj…. Tm are unknown breakpoints. The model estimation is done by minimizing the squares of the error terms of the coefficients of β and δj. Bai-Perron (2003) proposes following three testes in determining the number of breaks; (1) Sup Ft(n;k) test, (2) UDMaxFt (M,q) and WDMaxFt (M, q) tests and (3) Sup Ft (L+1 vs. L) test (Bai and Perron, 2003: 1-22). The number of breaks can also be determined using Schwarz and LZW information criterias. Liu, Wu, and Zidek (1997) proposed to use the modified Schwarz criterion to determine the number of breaks while LWZ offers theoretical results that display consistency of the estimated number of breakpoints and provide simulation results to guide the preference of the modified penalty criterion (Liu, Wu and Zidek, 1997: 497-525). The results of the Bai-Perron(2003) are as in the table given below.

Table 2. Bai-Perron (2003) Multiple Breakpoint Test Results

Global Information Criteria				
Number of Breaks	Sum of Sq Resids.	Log-L	Schwarz Criterion	LWZ Criterion
0	123.9860	-348.0841	-2.234247	-2.223893
1	117.4767	-316.6706	-2.276055	-2.244990
2	101.5351	-231.7218	-2.409769	-2.357991
3	89.72193	-159.6726	-2.521338	-2.448843
4	**80.40748**	**-95.82587**	**-2.618825**	**-2.525610**
5	85.70233	-132.9735	-2.542931	-2.428994
Sequential L + 1 Breaks vs. L				
Break Test	F-statistic	Scaled F-statistic		Critical Value**
0 vs 1*	64.44117	64.44117		8.58
1 vs 2*	182.4400	182.4400		10.13
2 vs 3*	152.6112	152.6112		11.14
3 vs 4*	133.8702	133.8702		11.83
4 vs 5	0.000000	0.000000		12.25
Global L breaks vs None				
Breaks	F-statisic	Scaled F-statistic	Weighted F-statistic	Critical Value
1*	64.44117	64.44117	64.44117	8.58
2*	128.4673	128.4673	152.6662	7.22
3*	147.7921	147.7921	212.7611	5.96
4*	157.1716	157.1716	270.2469	4.99
5*	103.5463	103.5463	227.2192	3.91
UDMax statistic*	157.1716		UDMax critical value**	8.88
WDMax statistic*	270.2469		WDMax critical value**	9.91
UDmax determined breaks				4
WDmax determined breaks				4

** Significant at the 0.05 level*

*** Bai-Perron (2003) critical values*

In this study, the number and the dates of breakpoints are initially determined by using the Schwarz and LZW information criterias. Estimated break dates are 12/2/1848, 16/7/1853, 16/1/1858, and 11/7/1863. According to Bai-Perron (2003), the LWZ and Schwarz criterions can yield higher values than they actually are and tend to determine more breaks in the time series in case of autocorrelation in error terms and proposed the supFT (L + 1 | L) test which uses the sequential estimations of breakpoints (Bai and Perron, 2003: 15). Thus the results obtained by Schwarz and LZW information criterias are compared with the other three tests proposed by Bai-Perron (2003). H0 hypothesis, which states that there is no break of the supFT(L) test statistics was rejected at a 99% confidence interval against the alternative hypothesis up to a maximum of 5 breaks. On the other hand, the null hypothesis of the UDmax and WDmax tests, the no structural break hypothesis was rejected at 99% confidence interval against the alternative hypothesis, which expresses the existence of m break at most. According to the results of sequential test supFT (L + 1 | L) the alternative hypothesis with L + 1 break against the H0 hypothesis with L break in case of L = 4 could not be rejected statistically at 99% confidence level. In this case, consecutive test results reveal that BoE reserves have 4 structural breaks and the breakpoint dates are consistent within each test.

To identify any possible regime break in the variance of reserve series, the Iterated Cumulative Sum of Squared Residual (ICSS) Algorithm is adopted. The ICSS algorithm was developed by Inclan and Tiao (1994) in order to detect multiple changes of variance in a sequence of independent observations since there are financial series that don't follow the usual assumption of constant variance underlying in most time series models (Inclan and Tao, 1994: 913; Malik, 2003: 219). The ICSS algorithm uses cumulative sums of squares to find breakpoints in a series by searching different pieces of series systematically and reveals the effect of shocks on the time series as a result of including the breakpoint dates determined in the unconditional variance of the error term into the volatility models used (Bjerkseth, 2006: 4). Thus, unexpected changes in the variance of financial series due to the shocks in financial markets caused by regional or global economic or political events can be identified. The model assumes that the data displays a stationary variance for a certain time until a structural change occurs from an event. The variance reverts to be stationary again until another structural change arises. This process repeats generating a time series of observations with unknown numbers of breakpoints in the variance (Sayani, 2011: 5).

The test statistics of the ICSS algorithm can be identified as max $\sqrt{(T/2)}$ |Dk|, here Dk = Ck/Ct – k/t, k = 1, 2,…..T, D0=Dt=0 where Ct is the sum of the squared residuals from the whole period of sample. In order to estimate the number of changes and the point in time of variance shifts, the cumulative sum of square residuals is used.

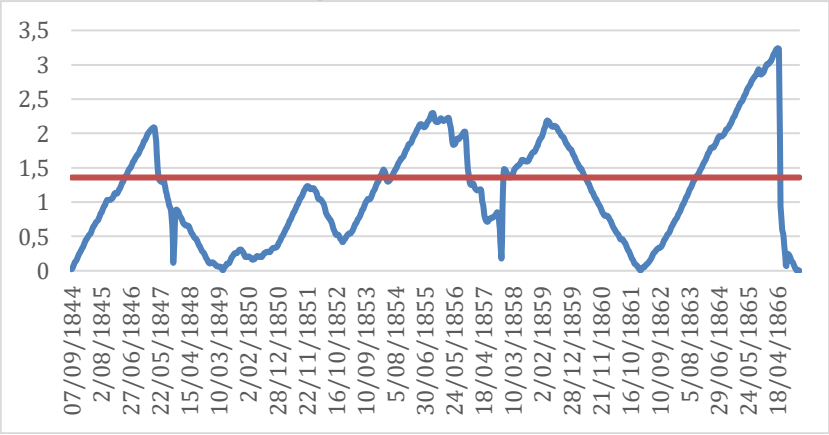
$C_k = \sum_{t=1}^{k} a_t^2$, Ck is the cumulative sum of squares of the random variable series with no correlation and variance of δt2, t = 1, 2, 3, …. T. For series with homogeneous variances, the plot of Dk fluctuates around zero. When there is an

abrupt change in variance, the graph of Dk patterns around specified boundaries with high probability (Gürsakal, 2009: 325). The critical values that determine the lower and upper limits for the drifts under the null hypothesis of stationary variance, ascertain the significant changes in the variance of the series. If the maximum absolute standardized value of the Dk is greater than the critical value, the null hypothesis of stationary variance is rejected (Sayani, 2011: 6). Dk function can give us only one breakpoint since if we want to find out more breakpoints in variance the Dk function became suspicious. The way to eliminate this drawback is to use iterative cumulative sums of squares. In this situation the test statistic is as below:

$$\max_{t_1 \le k \le t} \sqrt{(T - t_1 + 1)/2}\ \left| D_k\ (a[t_1 : T]) \right| \qquad (2)$$

Using this test statistic and performing multiple iterations, more than one variance breaks in the series can be detected (Inclan and Tiao, 1994: 196). If the test statistic is higher than the critical value, it is concluded that there is a variance break in the series. Then the ICSS process is repeated between t1 and the breakpoint k* found. In the end, the ICSS algorithm is continued iteratively until the test statistic is less than the critical value, that is, the no-break hypothesis can not be rejected. The results of the ICSS algorithm can be seen in the graphics below.

Graph 2. ICSS Test Statistic



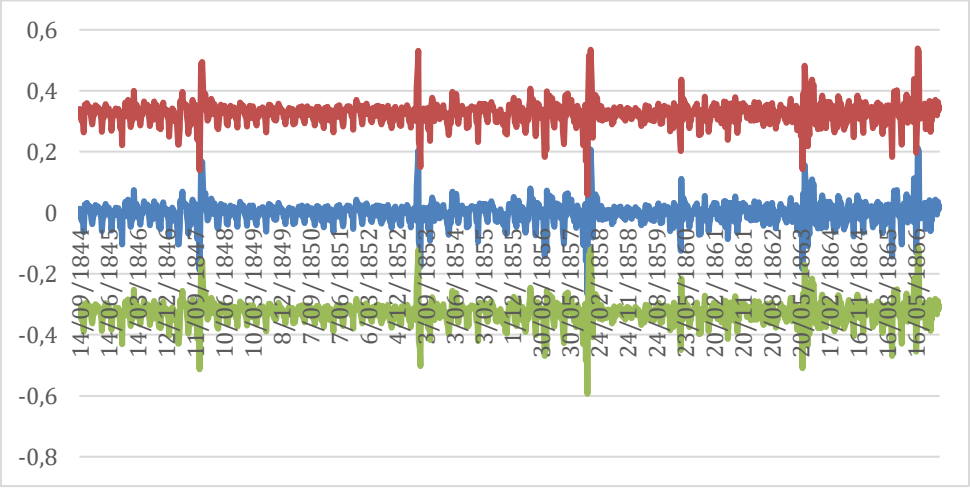
As can be seen from the graph the statistic of ICSS, exceeds the critical value of 1.358 in Inclan and Tiao (1994), many times. So we can decide that there are breaks in variance of the series. After having the signal that there are variance breaks in the series, the Cumulative Sum of Squares Algorithm was repeated iteratively many times to detect multiple variance breaks. As a result, breakpoint dates determined by the algorithm are, 02/05/1846, 18/02/1854-01/07/1854, 02/12/1857 and 28/10/1863. Possible structural breaks in the variance of the series affect the findings obtained from the analyzes made. In order to eliminate this drawback the possible breaks in the series were investigated with the break-in-variance test following Sanso et al. (2004) using Gauss 21 and the results obtained are presented in Table 3.

Table 3. Variance Break Dates for Yield Data

ICSS (IT)	ICSS (Kappa-1)	ICSS (Kappa-2)
03.03.1847	28.10.1863	19.12.1866
23.10.1847	19.12.1866	
01.12.1847		
03.09.1853		
02.12.1857		
28.10.1863		
20.09.1865		
02.05.1866		
22.08.1866		

The ICSS algorithm of Inclan-Tao detected 9 structural breaks while Kappa-1 algorithm detected 2 and Kappa-2 algorithm detected only 1 structural breaks. Because of the frequency effect, the number of structural breaks seem to be more when Sanso et al. (2004) is adopted in the analysis. However the break dates concentrates in the years 1847, 1853, 1857, and 1863 which obtained before.

Graph 3. Yield Data Compared with Standard Deviation



In order to visually demonstrate that the findings obtained from the structural break analysis are compatible with the structural breaks observed in the series, the standard deviation of the yield series of the reserve variable are calculated and presented in the graph below. As shown in the graph the break dates are consistent with the dates obtained from Bai-Perron structural breakpoint test and ICSS Algorithm results. The dates; 12/2/1848, 16/7/1853, 16/1/1858, and 11/7/1863 represent the breaks in the mean of the series and the dates; 02/05/1846, 03/03/1847, 23/10/1847, 01/12/1847, 03/09/1853, 18/02/1854, 01/07/1854, 02/12/1857, 28/10/1863, 02/05/1866, and 19/12/1866 represent the breaks in the variance.

When we evaluate chronologically the British Parliament repealed the Corn Laws, the legislation that controlled the importation of grain and removed the restrictive tariffs from British agriculture in June 1846 during the great famine

prevailing all over the island. But the speech of Prime Minister Sir Robert Peel on the repeal of the Corn Laws was just at the beginning of May 1846.

In 1847, both England and Ireland lived a deep economic crisis originated from the harvest failure in Ireland in 1846. The failure led to food shortages and drove up the commodity prices. As food imports from the USA and elsewhere surged, the trade deficit of Britain turned negative and reserves of the Bank of England drained out to finance food imports. The panic culminated in a "Week of Terror" in October 17-23rd with multiple bankruptcies and payment suspensions. This was the first time that the Bank Charter Act had to be suspended temporarily in response to the demand of London bankers (Dornbusch and Frenkel, 1984: 234).

The year 1848 was under the effect of the French Revolution all over the European continent. The 1848 Revolution in France is also known as the February Revolution. There were uprisings and disturbances in Italy and Denmark in January 1848, in Germany and Belgium in March. Some national banks had to suspend convertibility in the revolutionary troubles of 1848. According to the article of the Economist of Friday on 3 March 1848: the fluctuations in the public securities have been more sudden and greater during the last week of February than any time since the termination of the Continental War (Tooke and New march, 1857: 231; Kindleberger, 1984: 120). Again in February 1848, the Chartist movement which is a working-class movement for political reforms in the United Kingdom increased its activities to a broader extent following the arrival of the news related to the revolution in Paris.

The breaks that occur in 1853 and 1854 are closely linked with the Crimean War referring to the war-time functions of the BoE. The war actually started with the Russian invasion of the Danubian Principalities at the beginning of July 1853. The allies sent Russia an ultimatum to withdraw from Danubian Principalities it has conquered at the end of February 1854. The siege of Silistra was finished on the 23rd of June in 1854 and after the allies effectively involved in the war. The allies participated in the war in March 1854 but they contracted foreign loans for the War. An expenditure of nearly 90 million pounds was estimated to have been incurred by England. The foreign payments were largely made in specie, which to a great extent was hoarded in the East. The discount rate did not vary much but the reserves declined from 11,8 million to 6,9 million pounds in this period (Evans, 1859: 61). The influx of gold from Australia saved Britain from extreme commercial pressure during the early months of 1854. In this period the arrivals of gold and silver from Australia, America, and other quarters have been equal to more than ten million pounds (Francis, 1862: 412).

The breakpoints determined in 1857 and 1858 are closely linked with the commercial crisis of the period. The Crisis of 1857-58 is known as the first intercontinental financial crisis of modern capitalism. The crisis is related to the Crimean War by origin. The decrease in the demand for wheat from the USA after the Crimean War, caused the prices to be crashed. As European banks withdrew their deposits from American banks, the reserves melted and lending power decreased. With the weakening of economic activity and financial transactions

between Europe and the American continent, American railway stocks have shown speculative fluctuations (Allen, 2001: 215). During December 1857, numerous failures went on and as the government letter did not produce the desired relief immediately, it was feared early in the month that the pressure might be prolonged through the continuance of mercantile disasters. The Act of 1844 was suspended from December 12th to December 24th legally. Subsequently, the influx of specie from the USA and Hamburg created confidence and partial recovery. The large arrivals of Australian and American gold, with remittances from Turkey and Russia, rapidly augmented the stock of bullion, and the reserves reached a satisfactory position. Although the bank long previously attained a position to resume its ordinary functions, it was not until February, that the general panic diminished (Evans, 1859: 183; Andreades, 1909: 350). Thus we need to examine the breakpoints 02/12/1857 and 16/1/1858 together because the crisis lasted long and has deep global effects so it caused both the mean and the variance of the series break.

The abolishment of slavery in January 1863 and the American Civil War between 1861 and 1865 were two important developments that took place in the period. The breakpoints determined in 1863, do not directly address the abolition of slavery but correspond to the peak of the American Civil War. The Gettysburg Campaign between the 3rd of June and the 24th of July was the most severe one with 60 thousand losses. Supplies of cotton from America having practically ceased and the demand centered upon India. BoE had to support the drain of silver thither to help the payment for the cotton crop. So the bank rate increased rapidly (Warren, 1906: 190).

On the other hand, the causes of the crisis of 1866 started to show itself. The disorganization of the cotton trade, the confusion due to the export of gold, the fall in the rate of interest, and the accumulation of capital resulting from the extension in the use of machinery gave a speculative character to the English money market. The speculative tendency showed itself especially in a craze for limited liability companies. The shares issued in England reached the sum of 145 million pounds in 1863 (Andreades, 1909: 355). At the same time with the American Civil War there existed the Polish uprising in Russia. The insurrection spread to Lithuania and Belorussia. The newspapers dated October 28th, 1863, wrote about the Polish insurrection and informed that speculation and military reports cause hourly fluctuations in gold as a commercial intelligence (The Daily News, 28 October 1863: 5).

The simultaneous occurrence of many economic and political events, which are closely related to the Britan, has led to breaks in both the mean and the variance of the reserve series of the BoE. In some cases, the dates of breaks in mean and variance are very close to each other. The break in variance may indicate a change in the reserve policy of the BoE and can be interpreted as a shift from one regime to another. However, the Act, allowed the BoE to realize its reserve policy under strict constraints.

CONCLUSION

In this study, the relationship between the breaks in the BoE reserves and economic and non-economic factors was analyzed using structural breakpoint tests. The period of the study has some unique characteristics. This situation also increases the originality of the study. After the frequent and destructive crises at the beginning of the 19th century, the British Parliament both granted some monopolistic privileges and tied the functioning of the balance sheet of the BoE to a certain set of rules with the Act of 1844. The Act was implemented under intense discussions between the Currency and Banking schools. In this sense, the study sheds light partially and refers directly to the doctrinal debates.

Many important military, political, economic, and social developments took place in the period of the study. And it is not possible for Britain, who had absolute global superiority as of the period, not to be affected by regional and global developments. According to the results of the structural breaks tests, it is seen that the BoE reserves are also affected by these economic and non-economic developments and there are breaks in the mean and the variance of the reserve data. The breaks seen in both the mean and the variance of the reserve data occurred within the related event set.

Decisive developments as of the dates indicated by the breakpoints obtained as a result of econometric analysis; the abolition of the Corn Laws in 1846 as one of the most important policy moves to remove the restrictions on the foreign trade, revolutions of 1848 which were an extension of the French Revolution of 1789 and affected Europe severely in general, the Crimean War, the 1857/58 Crisis, the American Civil War and the uprisings in the Eastern Europe which were involved in the chain of events that resulted in the suspension of the Act in 1866. As can be seen, the dates addressed by the breakpoints reflect both economic and political developments. It is possible to further elaborate the reserve policies followed by the BoE with the help of models to be formed by adding discount rate data in the following studies.

Araştırma ve Yayın Etiği Beyanı

Makalenin tüm süreçlerinde Yönetim ve Ekonomi Dergisi'nin araştırma ve yayın etiği ilkelerine uygun olarak hareket edilmiştir.

Yazarların Makaleye Katkı Oranları

Makalenin tamamı Doç. Dr. Mehmet ÇETİN tarafından kaleme alınmıştır.

Çıkar Beyanı

Yazarın herhangi bir kişi ya da kuruluş ile çıkar çatışması yoktur.

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