Assessing the applicability of the expanded Taylor Rule within an inflation targeting framework: Empirical evidence from Türkiye

Genişletilmiş Taylor Kuralı'nın enflasyon hedeflemesi çerçevesinde uygulanabilirliğinin değerlendirilmesi: Türkiye'den ampirik kanıtlar

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ABSTRACT: According to Taylor, central banks should adjust the interest rates on short-term debt based on the gaps between current and potential output and the differences between current and target inflation. This approach, known as the Taylor Rule (TR), aims to promote consistency in central banks' actions and thus safeguard economic institutions against the challenges posed by uncertainty. While intricate policy regulations crafted by monetary authorities might be theoretically optimal, they tend to be burdensome for economic agents to adhere to. Conversely, the straightforward TR is more comprehensible and implementable. Unlike the original version proposed in 1993, this approach has been expanded to encompass the influence of exchange rates. In conclusion, this research investigates the practicality of the extended TR in the context of Türkiye, utilizing diverse datasets that contribute to the extended model. The study explores the viability of applying the extended TR to Türkiye using annual datasets from 1990 to 2022. To achieve this, tests for stationarity, cointegration, and long-run coefficients were conducted, with considerations for potential structural breaks. The test outcomes indicate that the policy interest rates in Türkiye do not correspond to the projections laid out in the extended TR.
Keywords: Taylor Rule, Interest, Inflation, Exchange rate, Income, Türkiye

ÖZ: Taylor'a göre merkez bankaları vadesi kısa olan borçların faiz oranlarını mevcut ile potansiyel hâsıla açıklıklarına ve hedeflenen enflasyon arasındaki farklara bağlı olarak ayarlamalıdır. Taylor Kuralı (TK) olarak bilinen bu yaklaşım, merkez bankalarının eylemlerinde tutarlılığı teşvik etmeyi ve böylece ekonomik kurumları belirsizliğin yarattığı zorluklara karşı korumayı amaçlamaktadır. Para otoriteleri tarafından hazırlanan karmaşık politika düzenlemeleri teorik olarak ideal olsa da ekonomik aktörlerin uyması için külfetli olma eğilimindedir. Tersine, basit TK daha anlaşılır ve uygulanabilirdir. Bu yaklaşım, 1993 yılında önerilen orijinal versiyonun aksine, döviz kurlarının etkisini de kapsayacak şekilde genişletilmiştir. Sonuç olarak, bu araştırma, genişletilmiş modele katkıda bulunan çeşitli veri kümelerini kullanarak, genişletilmiş TK' nın Türkiye bağlamında uygulanabilirliğini araştırmaktadır. Çalışma, 1990'dan 2022'ye kadar yıllık verileri kullanarak genişletilmiş TK'nın Türkiye'ye uygulanmasının uygulanabilirliğini araştırıyor. Bunu başarmak için, potansiyel yapısal kırılmalar dikkate alınarak durağanlık, eşbütünleşme ve uzun vadeli katsayılar için testler yapılmıştır. Test sonuçları, Türkiye'de politika faiz oranlarının genişletilmiş TK'nda ortaya konulan öngörülerle örtüşmediğini göstermektedir.
Anahtar Kelimeler: Taylor Kuralı, Faiz, Enflasyon, Döviz kuru, Gelir, Türkiye

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GENİŞLETİLMİŞ ÖZET

Giriş

Merkez bankalarının temel sorumluluğu fiyat istikrarını korumaktır ve çeşitli ülkeler bu hedefe ulaşmak için farklı stratejiler benimserler. 1990'larda uygulamaya konulan enflasyon hedeflemesi, 2006 yılında açık enflasyon hedeflemesi rejimine geçen Türkiye de dahil olmak üzere birçok ülkede benimsenmiştir. Finansal istikrar da 2008 krizi sonrasında önem kazanmış ve merkez bankalarının bunu fiyat istikrarının yanında değerlendirmesine yol açmıştır. Faiz oranlarının enflasyon ve çıktı açığına göre ayarlanmasına yönelik bir kılavuz olan Taylor Kuralı, para politikasının şekillendirilmesinde önem kazanmıştır. Bu kural, özellikle Türkiye gibi etkilerini önemli ölçüde yaşayan ekonomiler için döviz kurunu da kapsayacak şekilde genişletilmiştir. Türkiye'de enflasyon 2008'den sonra yüksek oranda artmaya başlamıştır. Bu durum ise faiz oranları ile döviz kuru arasındaki bağlantı nedeniyle genişletilmiş Taylor Kuralı'nı daha uygun hale getiriyor. Türkiye'nin merkez bankası ve yüksek enflasyon hakkındaki tartışmaların ortasında, bu çalışma, mevcut literatüre katkıda bulunmak amacıyla güncel verileri ve ampirik yöntemleri kullanmaktadır.

Literatür taraması

Taylor Kuralı'na ilişkin hem geleneksel hem de genişletilmiş versiyonları kapsayan daha önceki araştırmalar, çeşitli ülkeler, zaman dilimleri ve ampirik yöntemler genelinde incelenmiştir. Merkez bankaları için özellikle önemli olan bu kuralın belirsizliği azaltmadaki etkinliği araştırılmıştır. Bu çalışmalara örnek olarak güncel çalışmalardan Akdeniz ve Çatik (2019), Alkın ve ark. (2019), Coşar ve Köse (2019), Yalçınkaya ve Yazgan (2020), Kodaz ve Mangır (2021), Eroğlu ve Şeker (2022), Taş (2022) ve Pazarcı ve Akkoç (2023) verilebilir. Bu çalışmalar, enflasyonun ve üretim açıklarının faiz oranlarını etkilemedeki rolünü vurgulamakla birlikte bulgular farklı metodolojiler ve bağlamlar nedeniyle değişiklik göstermiştir. Döviz kurunu da içeren genişletilmiş Taylor Kuralı yaygın olarak incelenirken, belirli ülkeler ve dönemler arasında bazı sapmalar olmakla birlikte kuralın geçerliliği kabul edilmektedir.

Yöntem

Bu araştırma kapsamında Taylor Kuralı'nın genişletilmiş versiyonuyla birlikte uygulanabilirliği Türkiye ekonomisi için test edilmektedir. Bunu başarmak için 1990-2022 dönemini kapsayan yıllık veriler kullanılmıştır. Yararlanılan değişkenler üretim, enflasyon ve döviz kuruyla beraber faiz oranıdır. Çalışmada birim kök analizi için yapısal kırılmalı birim kök testleri kullanılmıştır. Bu amaçla yapısal kırılmanın içsel ve dışsal olarak belirlenebildiği Zivot-Andrews ve Perron birim kök testleri kullanılmıştır. Modelde eşbütünleşme ilişkisi için ise yapısal kırılmaların dikkate alındığı Gregory-Hansen eşbütünleşme testi kullanılmıştır. Son olarak açıklayıcı değişkenlerin faiz oranı üzerindeki etkisinin büyüklüğü ve yönü için FMOLS ve DOLS tahmincileri kullanılmıştır.

Bulgular ve tartışma

Genişletilmiş Taylor Kuralı'nın Türkiye için enflasyon hedeflemesi çerçevesinde uygulanabilirliğine ilişkin 1990-2022 dönemini kapsayan araştırmada önemli bulgular ortaya çıkmıştır. Sabit model için Zivot-Andrews (ZA) ve Perron birim kök testleri analiz edildiğinde her iki testin sonuçlarında tutarlı bir örüntü ortaya çıkmaktadır. Bu model, esas olarak 1999 ile 2005 yılları arasına düşen kırılma noktalarının ve ağırlıklı olarak sıfır gecikme uzunluklarının varlığıyla da desteklenmektedir. Ayrıca test sonuçlarının hem Zivot-Andrews hem de Perron kritik değerleri için %10'un altında kalan istatistiksel anlamlılığı, tüm değişkenlerin düzey değerlerinde birim kök özelliklerine sahip olduğunu göstermektedir.

Diğer yandan herhangi bir eşbütünleşme ilişkisinin bulunmadığını öne süren eşbütünleşmenin temel hipotezi, genişletilmiş Taylor Kuralı bağlamında incelenmiştir. Sonuçların kapsamlı bir incelemesi, ADF ve Zt için sırasıyla %10 ve %1 anlamlılık düzeylerinde kritik değerleri aşan test istatistikleriyle desteklenen, başlangıç hipotezinin reddedildiğini ortaya koymaktadır. Sonuç olarak alternatif hipotez desteklenmektedir. Bununla birlikte, Za sonuçlarının daha yakından incelenmesi üzerine, test istatistiği değeri kritik değerlerin altına düştüğü için birincil hipotez tartışmasız kalır. ADF ve Zt testlerinin birleşik sonuçları, öngörülen zaman dilimi boyunca model içindeki değişkenlerin birlikte hareket ettiğini vurgulayarak, birbirine bağlı dinamiklerinin daha derinlemesine anlaşılmasına katkıda bulunur.

Ayrıca model değişkenlerinin büyüklükleri ve yönlerinin değerlendirilmesi tutarlı sonuçlar ortaya koymaktadır. Belirlenen zaman diliminde Türkiye'de faiz etkisi en çok döviz açığından şekilleniyor, enflasyon açığından ise en az pozitif etkileniyor. Tam tersine, üretim açığı ise Türkiye'nin faiz oranını olumsuz etkiliyor. FMOLS (DOLS) sonuçlarına göre katsayılar, döviz açığı ve enflasyon açığındaki %1'lik artışın faiz oranında sırasıyla %8,56 ve %2,71 (%9,84 ve %2,75) artışa yol açtığını göstermektedir. Tam tersine, üretim açığındaki %1'lik bir artış, faiz oranında %0,07 (%0,10) bir düşüşe yol açmaktadır.

Sonuç ve öneriler

Sonuç olarak, Genişletilmiş Taylor Kuralı'nın Türkiye için 1990'dan 2022'ye enflasyon hedeflemesi çerçevesinde uygulanabilirliğini inceleyen çalışma, ülkenin ekonomik manzarasını şekillendiren önemli dinamiklere ışık tutmuştur. Enflasyon, ekonomik büyüme ve döviz kurları ekonomik istikrarı etkileyen temel göstergeler olarak yer almakta ve merkez bankaları bu değişkenlerdeki dalgalanmaları yönlendirmek için Taylor Kuralı gibi para politikalarından yararlanmaktadır.

Ampirik bulgular, Türkiye'de faiz oranlarının döviz açığı, üretim açığı ve enflasyon açığına önemli ölçüde tepki verdiğini ortaya koyuyor. Döviz açığının olumlu etkisi yabancı yatırımları çekmedeki rolünü vurgularken, üretim açığı ile ters ilişki yerli üretim seviyelerinin önemini vurgulamaktadır. Ayrıca enflasyon açığının faiz oranları üzerindeki olumlu etkisi fiyat istikrarını koruma çabalarıyla paralellik göstermektedir.

Faiz oranlarının dengelenmesi ekonomik istikrar açısından büyük önem taşımaktadır. Yüksek oranlar enflasyonu frenleyebilir ancak ekonomik büyümeyi yavaşlatabilir; düşük oranlar ise yatırımı teşvik edebilir ancak enflasyonist baskı riskini doğurabilir. Bu nedenle, politika oluşturmanın daha geniş ekonomik bağlama uygun hale getirilmesi gerekmektedir.

Gelecekteki araştırmalar için, Genişletilmiş Taylor Kuralı'nın, Türkiye'nin de dahil olduğu "kırılgan beşli" veya E7 ülkeleri gibi bir ekonomi veri seti genelinde karşılaştırmalı analizini daha geniş bir kapsam kapsayabilir. Bu yaklaşım, benzer zorluklarla boğuşan çok çeşitli ekonomiler için kapsamlı bilgiler ve politika önerileri sağlayabilir.

Introduction

Maintaining price stability, a pivotal macroeconomic objective, stands as a primary responsibility for central banks. The pursuit of price stability takes distinct forms depending on individual country contexts. The adoption of inflation targeting strategies, introduced during the 1990s, has been embraced by numerous nations (Şeker and Öngel, 2022). This approach establishes a significant policy framework for monetary authorities. Within this framework, central banks strive to secure price stability through the influence of expectations. Türkiye's monetary policy underwent substantial changes after the early 2000s crises. A noteworthy transformation was the adoption of an implicit inflation targeting regime in 2002 (Özbek, 2023: 519). The government initiated the transition to an explicit inflation targeting regime in 2006. Another change pertained to the autonomy granted to the Central Bank of the Republic of Türkiye (CBRT) in wielding policy instruments (Pazarcı and Akkoç, 2023: 262).

The global financial crisis in 2008 prompted policy shifts across numerous central banks. The infusion of liquidity following this crisis complicated its management. Consequently, financial stability became a focal concern. In this context, the CBRT began considering financial and price stability starting in 2010. To this end, mitigating macroeconomic instability involved disrupting the credit channels of short-term capital flows (Kara, 2012). Alongside financial stability, central banks also began monitoring exchange rate levels (Naimoğlu and Özbek, 2022). The resulting crises led to heightened effectiveness of monetary policies, accentuating control over money supply and credit volume within economies. This circumstance raised debates on the regularity of monetary policies, a topic frequently deliberated within economic literature (Eroğlu and Şeker 2022: 590). These discussions are theoretically underpinned by Keynesian and Monetarist perspectives. The Monetarist perspective supports policies that follow specific rules, while the Keynesian perspective emphasizes the need for monetary authorities to have flexibility in their policy execution, as noted by Tunay (2007: 224). Furthermore, in the framework of the New Keynesian perspective, monetary policy has taken a more prominent role, displacing the previous emphasis on fiscal policy, as discussed by Tetik et al. (2022: 65).

Categorization of rules within standard monetary policies entails the classification of "intermediate rules" and "target rules." Target rules encompass regulations that commit to achieving specific values in variables like inflation rate and money supply. Among the instrumental rules, the Taylor Rule (TR) holds the utmost significance (Büyükakın, 2004). The Taylor Rule (TR), developed by Taylor (1993), functions as a framework for assessing how inflation and output gaps react to variations in the interest rate. Essentially, the TR can be characterized as a principle that measures the modification of the interest rate when deviations from the inflation and output targets occur. Given its comprehensibility, this rule can contribute to shaping the anticipations of economic entities. Within the framework of this rule, monetary authorities respond by raising interest rates in times of inflation and output gaps, while lowering them in the opposite scenario (Peker and Sümer, 2018). Familiarity with this consistent mechanism among economic entities is deemed crucial for informed decision-making. Consequently, it facilitates the management of future expectations. As a result, the easily comprehensible TR has evolved into a frequently employed framework for monetary policy. The traditional formulation of the TR is presented as follows;

$$\iota = \tau + \pi + a_1(\pi - \pi^*) + a_2(y - y^*) \qquad (1)$$

"Equation (1) encompasses the elements i, r, π, π*, y, and y*, which stand for the policy interest rate, actual interest rate, expected inflation rate, desired inflation rate, current output level, and potential output level, as described in Taylor's work from 1993". On the other hand, the coefficients corresponding to the inflation gap and output gap are indicated as a1 and a2, respectively. The coefficient a1 reflects how the inflation gap reacts to alterations in the policy interest rate, while the parameter a2 means how the production gap responds to changes in the policy interest rate. However, the conventional TR does not encompass the exchange rate within its framework. Nevertheless, the deepening process of globalization during the 1990s led to increased capital mobility (Demir and Sever, 2009), causing significant shifts particularly in economies reliant on foreign factors. The 2008 global crisis stands as one of the indicators of this phenomenon. As a result, in the realm of conventional monetary policy, the classical TR has been broadened to include the exchange rate factor. Taylor (2001) introduced the extended TR, which is expressed as follows:

$$\iota = \tau + \pi + a_1(\pi - \pi^*) + a_2(y - y^*) + a_3(e - e^*) \quad (2)$$

The parameter denoted as "a3" in the extended TR, as presented in equation (2), represents the coefficient for the response to exchange rates, connecting fluctuations in the exchange rate to changes in the policy interest rate, as explained by Yalçınkaya and Yazgan (2020: 41). To put it differently, the value of the coefficient "a3" signifies the flexibility of monetary policy about the short-term nominal interest rate concerning variations in the exchange rate. When all coefficients, "a1," "a2," and "a3," are set to zero in the latter equation, it implies that there is no need for monetary authorities to modify the policy interest rate. Nonetheless, in this scenario, the adjustments to the interest rate within the extended Taylor Rule should be based on the exchange rate in addition to inflation and deficits. If these disparities are positive or negative, monetary authorities make corresponding adjustments to the short-term policy interest rates, thus establishing the equilibrium real interest rate, as discussed by Albayrak and Abdioğlu (2015).

Türkiye, categorized as a developing economy, experiences substantial impacts from fluctuations in the exchange rate. Given its foreign energy dependence, Türkiye is compelled to effectively execute its monetary policy to mitigate inflationary pressures (Ceylan and Başer, 2014). Following the 2008 global crisis, inflation escalated in Türkiye, reaching double-digit levels in 2017. Despite a targeted inflation rate of 5%, inflation soared to 11.92% by 2017. Subsequent years saw rates of 20.3%, 11.84%, 14.60%, and 36.3%, respectively. The year 2022 marked a record high in recent history with a rate of 64.27% (TUIK, 2023). Corresponding with these inflationary surges, there was an increase in the exchange rate. Consequently, employing the extended exchange rate TR rather than the conventional TR seems more appropriate for the monetary policy framework. Including the exchange rate in the model offers the potential for implementing measures to enhance financial stability and monitor global capital mobility.

In Türkiye, discussions surrounding both the CBRT and inflation have gained considerable attention. This period, characterized by simultaneous economic measures and soaring inflation rates, serves as the principal impetus for this study. The utilization of contemporary datasets and empirical methods sets this study apart. In this context, the study is anticipated to make a valuable contribution to the existing literature.

The subsequent section of the research provides an overview of earlier studies related to the topic. Moving on to the third segment, the dataset and model are introduced, accompanied by the presentation of empirical results. The final part comprises assessments, delineation of policy suggestions, and the study's conclusion.

Literature review
This segment will provide an overview of earlier research about Taylor's Rule. Within this examination, the body of literature encompassing both the conventional TR and its expanded counterpart will be introduced. This review of scholarly works holds significance for the comparative analysis of the said rule. Notably crucial for central banks, Taylor's Rule is a notable practice and a potent instrument for mitigating uncertainty. The assessment will encompass diverse countries, timeframes, and empirical approaches, further underscoring its importance.

Ongan (2004) examined the validity of Taylor's Rule within the Türkiye context during the period spanning 1988:01 to 2003:03. The choice was to utilize deposit interest rates as the representative variable for interest rates. Employing regression analysis as the empirical technique, the study concluded that interest rates shared a statistically significant correlation with both inflation and the nominal exchange rate. This outcome indicated that, within the relevant timeframe, interest rates in the Türkiye economy exhibited behavior akin to rule-based actions. Çağlayan (2005), also investigating Taylor's Rule's applicability in Türkiye, opted for the multinomial logit model as the empirical approach. Analyzing data from 1990:03 to 2004:12, the empirical findings indicated that the production gap did not hold a significant role in determining interest rates. Conversely, it was inferred that the lag in the production gap after one period and the deviation in inflation played vital roles in influencing interest rates. In a similar, Kaytancı (2005) employed the Extended Taylor Rule and VAR models to investigate the monetary policy response mechanism of the CBRT during the same year. He utilized quarterly data

spanning from 1990:1 to 2003:4 as the study period. According to the findings, the overnight interest rate exhibited a negative and statistically insignificant response to shocks in the exchange rate or overnight interest rates, and to deficits in output and inflation. This suggests that a commitment to short-term interest rates alone is insufficient to address the inflation problem.

Leiderman et al. (2006) undertook an examination of the economies of Peru, Bolivia, Chile, and Colombia. The study revealed a pronounced responsiveness of the monetary authorities in all the aforementioned countries to the inflation gap. Teles and Zaidan (2010), in their assessment of central bank policies aimed at ensuring price stability across twelve countries, Türkiye included, within the framework of Taylor's Rule, chose the TAR method as their empirical approach. Empirical discoveries underscored the significance of factoring in expectations by monetary authorities to uphold price stability. Within this context, the conclusion was drawn that adherence to long-term plans was essential. Among the countries scrutinized, including Türkiye, Brazil, and Poland, it was determined that Türkiye, Brazil, and Poland aligned with the TR. Erdem and Kayhan (2011) examined the applicability of the Taylor Rule (TR) in Türkiye between 2002, the commencement of the implicit inflation targeting regime, and 2009. They employed VAR analysis and assessed distinct time periods corresponding to the tenures of central bank governors Süreyya Serdengeçti and Durmuş Yılmaz. The empirical findings revealed that the TR was more suitable during Süreyya Serdengeçti's term compared to Durmuş Yılmaz's period.

Sghaier (2012), in a test of the applicability of the TR within the Tunisian economy, concluded that the central bank adhered to the TR based on its quarterly data spanning 1993:2 to 2011:4. In an investigation concerning the Colombian economy, Villa et al. (2014) unveiled a situation wherein monetary authorities responded solely to the output gap prior to the adoption of inflation targeting, shifting their focus exclusively to inflation changes post the implementation of inflation targeting. Pehlivanoğlu (2015) delved into the applicability of the TR within Türkiye for the period spanning 1987:1 to 2013:3, utilizing quarterly data and forward-looking expectations to make predictions, ultimately confirming the rule's validity. Almounsor (2015) examined the reaction function of Saudi Arabia's central bank. The study concluded that the central bank did not adhere to the TR and that the behavior of the interest rate was significantly influenced by the Fed rate. In their study, Berüment and Malatyalı (2000) revealed that monetary authorities responded to inflation and the output gap in determining interest rates, but not to changes in the exchange rate. Aklan and Nargeleçekenler (2008), conducting a similar investigation, demonstrated that interest rates aligned with the rule. Their study indicated that the response to changes in the exchange rate was less pronounced compared to the response to inflation and the output gap.

Civcir and Akçağlayan (2010), who argued for a greater reaction to the exchange rate than the output gap, established that alterations in the exchange rate following 2001 played a crucial role in determining interest rates. Lebe and Bayat (2011) assessed the validity of Taylor's Rule in the Türkiye economy, employing three distinct interest rate models. Their findings indicated that the rule held true in all models, with more fitting outcomes observed in the model utilizing the rediscount interest rate. Demirbaş and Kaya (2012) scrutinized the applicability of Taylor's Rule within the Türkiye economy over the sampling period from 2001 to 2012. Their empirical model incorporated variables such as overnight interest rate, output gap, inflation gap, and real exchange rate. The ARDL limit test was the selected practical approach. Empirical results affirmed the validity of Taylor's Rule. Ardor and Varlık (2014) explored the viability of the forward-looking TR, the McCallum rule, and the Taylor-McCallum Hybrid rule by merging the two, within the period of 2002 to 2012 in the Türkiye economy. Using the GMM method as their empirical approach, the study indicated that the McCallum (1997) rule and the Taylor-McCallum Hybrid rule lacked validity within that period. Gögül and Songur (2016), in their examination of the TR employing the deposit interest rate, assessed the years from 2006 to 2015. Adopting the ARDL boundary test as their empirical method, they concluded that the CBRT adhered to the TR following the implementation of inflation targeting.

For Türkiye in open economy settings and the period of 2001:08 to 2016:06, Bal et al. (2016) investigated Taylor's Rule. Employing the decomposition analysis by Beveridge and Nelson (1981), empirical results affirmed the validity of Taylor's Rule. Aydınlık (2017) conducted an examination of

the extended TR, which incorporates exchange rate and financial variables, utilizing the ARDL bounds test. The results of the study confirmed the credibility of the extended TR. In an extended time, frame spanning from 2006 to 2015, Alkın et al. conducted an assessment of the TR's validity, employing the asymmetric causality test. Their findings also supported the credibility of the TR. Coşar and Köse (2019) assessed the financial stability index within an expanded TR framework, utilizing the Kalman Filter Method and observing the period of 2002 to 2017. The outcomes showed that the CBRT's policy rate was affected by the financial stability indicator. Likewise, Altunöz (2019) assessed the applicability of both the conventional and extended Taylor Rules using the ARDL model from 2004 to 2016. The empirical results indicated that both models adhered to a defined pattern in the behavior of the interest rate, demonstrating their validity.

Akdeniz and Çatık (2019) expanded the TR with financial variables within the 2006 to 2016 period, employing the threshold GMM method. Empirical outcomes indicated the validity of Taylor's Rule under financial conditions. Yalçınkaya and Yazgan (2020) assessed the traditional and extended TR using quarterly data from 2002:1 to 2019:2 in the Türkiye economy. Their empirical methods included linear and non-linear time series analyses, both of which supported the validity of Taylor's Rule. Kodaz and Mangır (2021) investigated the extended TR across selected economies that adopted inflation targeting, covering the time frame of 2001 to 2020. Employing panel data methods, their study concluded that the interest rate played a significant role in achieving price stability within the relevant group of countries. Results indicated that the interest rate took the inflation gap and the output gap into consideration, but not the exchange rate. Eroğlu and Şeker (2022), in their exploration of the validity of both the traditional and extended TR within Türkiye from 2006 to 2021, employed the ARDL limit test as their chosen empirical method. The empirical findings revealed that in both models, the interest rate factored in both production and exchange rate variables.

Smilarly, Taş (2022) assessed the validity of the extended TR from January 2011 to May 2022, using the Fourier cointegration test. The outcomes of the study indicated that the rule remained effective. In the study conducted by Pazarcı and Akkoç (2023), the validity of the TR was examined across two distinct periods, aligned with the presidencies of Erdem Başçı (2011: 04-2016: 03) and Murat Çetinkaya (2016: 04-2019: 07) at the CBRT. The empirical model included factors such as the CBRT's weighted average funding cost, inflation rate, industrial production index, and the USD/TL exchange rate. The results of the impulse response analysis demonstrated a heightened response by the CBRT to exchange rate fluctuations in both time periods, with no significant reaction observed to shocks in the industrial production index. The magnitude of these structural changes differed between the two periods. Compared to the Başçı period, there was a more significant adjustment in interest rates during the Çetinkaya period. Considering the extensive scope of the literature, it becomes evident that the TR, extended to include the exchange rate gap, is commonly examined. While empirical results do not uniformly converge, it has been recognized that both inflation and the production gap play pivotal roles in influencing interest rates. Variations in outcomes are likely attributed to methodological approaches, specific countries, and timeframes.

Methodology
Within this portion, the extended TR is subjected to examination in the Türkiye context through the incorporation of the exchange rate variable. This endeavor involves the utilization of time series analysis techniques. In the subsequent Methodology segment, the initial focus is directed towards the introduction of both the dataset and the model. This is followed by provising methodological details, which are subsequently followed by a comprehensive discussion of the findings.

Model and data
The model to be investigated is as follows:

$$INT_t = \delta_0 + \delta_1(\pi - \pi^*)_t + \delta_2(y - y^*)_t + \delta_3(e - e^*)_t \quad (3)$$

Various techniques are employed for calculating potential macroeconomic variable values, specifically for deriving equilibrium values over the long term. In the present research, the Hodrick-Prescott (HP) filtering method, was employed to ascertain potential values. The econometric applications were

executed using the Eviews 12 software package. Subsequently, in the ongoing investigation, the interest rate will be represented by "INT," the inflation gap by "PI," the production gap by "GDP," and the exchange rate gap by "OER." Logarithmic transformations will be applied to all variables.

Unit root test

In this section of the research, the stability of the variables will undergo assessment through the application of the Zivot and Andrews (1992) (Z&A) and Perron (1989) tests, designed to accommodate potential structural breaks. Subsequently, the investigation will extend to examining cointegration relationships using the methodology outlined by Gregory and Hansen (1996) (G&H). Following this, for the purpose of obtaining long-term coefficient estimates and error correction terms, the study will employ the FMOLS and DOLS tests.

Z&A internally identified the date of the structural break within the unit root test they formulated, and their models were elaborated upon in the following manner.

$$\gamma_t = \omega + \delta t + \sigma \gamma_{t-1} + \theta_1 DmyT(\varphi) + \sum_{i=1}^{k} c_i \Delta \gamma_{t-i} + e_t \qquad \text{(Model1)}$$

$$\gamma_t = \omega + \delta t + \sigma \gamma_{t-1} + \theta_2 DmyU(\varphi) + \sum_{i=1}^{k} c_i \Delta \gamma_{t-i} + e_t \qquad \text{(Model2)}$$

$$\gamma_t = \omega + \delta t + \sigma \gamma_{t-1} + \theta_1 DmyU(\varphi) + \theta_2 DmyU(\varphi) + \sum_{i=1}^{k} c_i \Delta \gamma_{t-i} + e_t \quad \text{(Model3)}$$

Model1 above is "constant", Model2 is "trend", and Model3 depicts a situation in which structural break affects both "constant" and "trend". On the other hand, DmyT represents the dummy variable for the trend and DmyU the dummy variable for the constant term. $\Delta \gamma_{t-i}$ was added to the model to avoid potential autocorrelation between residues. Perron, on the other hand, developed the following models under her main hypothesis.

$$\gamma_t = \omega + \sigma \gamma_{t-1} + \delta_1 DmyT_t + e_t \qquad \text{(Model4)}$$

$$\gamma_t = \omega + \sigma \gamma_{t-1} + \delta_2 DmyU_t + e_t \qquad \text{(Model5)}$$

$$\gamma_t = \omega + \sigma \gamma_{t-1} + \delta_1 DmyT_t + \delta_2 DmyU_t + e_t \qquad \text{(Model6)}$$

In Perron, as in Z&A, Model4 is 'constant', Model5 is 'trend', and Model6 describes a situation in which structural break affects both 'constant and 'trend'. On the other hand, DmyT represents the dummy variable for the trend and DmyU the dummy variable for the constant term.

Cointegration test and estimators

In the analysis of cointegration proposed by G&H, they incorporated the structural break directly into the model. Similar to the approach observed in unit root tests concerning structural breaks, the cointegration assessment by G&H comprises three models, which are explained in further detail below.

$$\gamma_{1t} = \omega_1 + \mu_2 \varphi_{tr} + \sigma^T \gamma_{2t} + \varepsilon_t \qquad \text{(Model7)}$$

$$\gamma_{1t} = \omega_1 + \mu_2 \varphi_{tr} + \beta t + \sigma^T \gamma_{2t} + \varepsilon_t \qquad \text{(Model8)}$$

$$\gamma_{1t} = \omega_1 + \mu_2 \varphi_{tr} + \sigma_1^T \gamma_{2t} + \sigma_2^T \gamma_{2t} \varphi_{tr} + \varepsilon_t \qquad \text{(Model9)}$$

In this context, μ_1 and μ_2 represent the constant disruption, a_1 symbolizes the pre-break bending coefficient, and a_2 signifies the post-break shift in the slope parameter (Gregory and Hansen, 1996:103). The statistical equations employed for the cointegration test in the G&H Philips test are presented as follows (Gregory and Hansen, 1996: 106).

$$Z_a^* = \inf_{\tau e T} Z_\sigma(\tau) \qquad \text{(Model10)}$$

$$Z_t^* = \inf_{\tau e T} Z_t(\tau) \qquad \text{(Model11)}$$

$$ADF^* = \inf_{\tau e T} ADF(\tau) \qquad \text{(Model12)}$$

The test statistics Z_σ^*, Z_t^*, and ADF^* acquired from these examinations are juxtaposed against the critical thresholds outlined in G&H research. Subsequently, the fundamental assumption of the absence of a cointegration relationship is evaluated.

The outcome of the cointegration verifies a connection between the variables, demanding the calculation of extended-term coefficients. To achieve this goal, we will estimate the long-term coefficients. The Fully Modified Ordinary Least Squares (FMOLS) technique, as introduced by Phillips and Hansen (1990), will be applied to mitigate potential endogeneity issues. Simultaneously, concerns arising from interaction and autocorrelation among explanatory variables and residuals will be resolved using the Dynamic Ordinary Least Squares (DOLS) approach, formulated by Stock and Watson (1993).

Empirical results and discussion

Correlation coefficients play a crucial role within econometric analysis by aiding in the comprehension of variable relationships, facilitating predictions, and guiding the selection of independent variables in more intricate analyses. Before conducting the analysis, correlation coefficients were computed and are showcased in Table 1. Upon reviewing the table, it becomes evident that all variables exhibit minimal correlation with both the dependent variable and one another.

Table 1: Correlation results

	INT	GDP	PI	OER
INT	1			
GDP	-0.101	1		
PI	0.209	0.200	1	
OER	-0.065	0.666***	-0.177	1

Note: ***(1%) is level of significance.

In tests for structural breaks and unit roots, using an externally determined break date, which assumes independence, is not reliable for ensuring the consistency of the tests. This led to criticism of Perron's (1989) work, where the externally determined break date was seen as problematic. Consequently, this criticism prompted the advancement of unit root tests that internally determine the break date.

The unit root test results of Z&A and Perron for assets with structural breaks are shown in Table 2.

Table 2: Unit root test results

Zivot and Andrews (Z&A)	Test Statistic	Lag	Break Date
INT	-3.138	4	2000
Pİ	-3.808	0	2003
OER	-4.492	0	2005
GDP	-3.539	2	2005
Perron	**Test Statistic**	**Lag**	**Break Date**
INT	-3.220	4	1999
Pİ	-3.74	0	1999
OER	-4.421	0	2004
GDP	-3.411	0	2004
Critical Values	ZA: %1=-5.34, %5=-4.93, %10=-4.58, Perron: %1=-5.92, %5=-5.23, %10=-4.92		

Upon reviewing Table 2, the findings from the Z&A and Perron unit root tests have been incorporated for the fixed model. Consistency is observed in the outcomes of both tests. Upon closer examination of the results, the breakpoints for all variables tend to fall between the years 1999 and 2005. Conversely, the lag lengths predominantly remained at 0. Furthermore, the test statistics results for both Z&A and Perron critical values demonstrated significance levels below 10%. Hence, it can be deduced that all variables exhibit unit root characteristics at the level values.

The existence of a cointegration link within the model was examined by utilizing the G&H *cointegration* test, and the results are showcased in Table 3.

Table 3: Cointegration test results

Tests	Test Statistics	Lag	Break Date	Critical Values
ADF	-7.139*	0	2001	1%=-6.51, %5=-6.00, %10=-5.75
Zt	-7.253***	-	2001	
Zσ	-40.948	-	2001	1%=-80.15, %5=-68.94, %10=-63.42

Note: ∗(10%), ∗∗(5%) and ∗∗∗(1%) are levels of significance.

The primary assumption underlying the concept of cointegration is the absence of any cointegrating relationship. Upon reviewing Table 3, the initial hypothesis is refuted due to the fact that the test statistics values for ADF and Zt exceed the critical values at significance levels of 10% and 1%, respectively. Consequently, the alternative hypothesis is supported. However, upon scrutinizing the Za results, the initial hypothesis remains unchallenged as the test statistic value falls below the critical values. As a result, based on the outcomes of both the ADF and Zt tests, it can be inferred that the variables within the model move together during the specified timeframe.

Given the identification of a cointegration relationship within the model, the results of FMOLS and DOLS estimations for calculating long-short term coefficients are displayed in Table 4.

Table 4: Long-run coefficient estimation results

INT	GDP	PI	OER	DU	C
FMOLS	-0.074***	2.710***	8.561***	-75.272***	88.796***
	(0.019)	(0.719)	(1.810)	(6.940)	(6.044)
DOLS	**-0.104***	**2.750****	**9.839***	**-70.902***	**87.083***
	(0.028)	**(1.052)**	**(2.697)**	**(9.267)**	**(8.114)**

Note: ∗∗(5%) and ∗∗∗(1%) are levels of significance. DU is dummy variable.

Upon reviewing the table, it becomes apparent that the magnitudes and directions of the variables yielded comparable findings. In the specified timeframe, the impact of Türkiye's interest rate is most positively influenced by the exchange rate deficit, while being least influenced by the deficit in inflation. Conversely, the production gap exerts a negative influence on Türkiye's interest rate. Evaluating the coefficients, in terms of the FMOLS (DOLS) outcomes, a 1% augmentation in the exchange rate deficit and inflation deficit results in an elevation of 8.56% and 2.71% (9.84% and 2.75%) in the interest rate, respectively. On the contrary, a 1% growth in the production gap leads to a decrease of 0.07% (0.10%) in the interest rate.

Conclusion and policy implications

In national economies, inflation, economic growth, and exchange rates are fundamental economic indicators. The significance of these variables stems from their broad impact across society. Central banks employ monetary policies to proactively respond to fluctuations or deviations in these variables. One approach advocated by economists favoring a standardized approach is the TR, which has evolved due to globalization, now encompassing the exchange rate as well. Consequently, the intention is to determine interest rates based on these three mentioned variables. The chosen level of policy rates, the rise in foreign currency influx, and the preservation of investment expenditures - essentially, upholding equilibrium between the financial and real sectors - hold paramount importance. This dynamic holds weight not only for economic entities but also for policymakers.

In the context of this investigation, the applicability of Taylor's Rule, including its expanded version, is tested within the Türkiye economy. To achieve this, interest rate, inflation gap, production gap, and exchange rate gap are utilized as yearly data spanning the period from 1990 to 2022. The study employs the Z&A and Perron tests for unit root analysis, the G&H test for cointegration, and FMOLS and DOLS methods for long-term coefficient estimation. According to the empirical findings, interest rates in Türkiye are most influenced positively by the exchange rate deficit and inversely by the production deficit. Furthermore, the inflation gap exhibits a favorable impact on interest rates. The exchange rate gap may cause the domestic currency to depreciate against foreign currencies, attracting investors. This makes the investment attractive. However, this can increase inflation and central banks can fight

inflation by raising interest rates. High interest rates can increase demand for the local currency, but slow the economy and increase unemployment.

Low interest rates, on the other hand, can reduce savings, encourage risky investments, raise asset prices excessively, increase consumer spending, and create inflationary pressure. Also, low interest rates can reduce investors' demand for the local currency, raise capital abroad, and reduce the attractiveness of long-term investments. Furthermore, the test outcomes indicate a lack of alignment between the policy interest rates in Türkiye and the forecasts outlined in the extended TR. This discrepancy could be attributed to global economic cycles and the uncertainties stemming from the Russia-Ukraine conflict. Additionally, it could result from alterations in policy and exchange rate fluctuations introduced by successive changes in Central Bank leadership in Türkiye, particularly concerning inflation targeting. For this reason, it is important for Türkiye's macroeconomic stability to set interest rates in a balanced way and to follow policies suitable for general economic conditions.

In subsequent research endeavors, the expanded TR could be assessed using a dataset encompassing the vulnerable "fragile five" or E7 nations, including Türkiye. This approach would allow for the formulation of more comprehensive policy suggestions.

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Ethical approval

This study is among the studies that do not require ethics committee approval due to use of secondary data.

Conflict of interest

There is no potential conflict of interest in this study.