ECONOMIC POLICY

Bundesministerium der Finanzen

76th Economic Policy Panel Meeting

20- 21 October 2022

Exchange Rate and Inflation under Weak Monetary Policy: Turkey Verifies Theory

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Abstract

For the academic audience, this paper presents the outcome of a well-identified, large change in the monetary policy rule from the lens of a standard New Keynesian model and asks whether the model properly captures the effects. For policymakers, it presents a cautionary tale of the dismal effects of ignoring basic macroeconomics. In doing so, it also clarifies how neo-Fisherian disinflation may work or fail, in theory and in practice. The Turkish monetary policy experiment of the past decade, stemming from a belief of the government that higher interest rates cause higher inflation, provides an unfortunately clean exogenous variance in the policy rule. The mandate to keep rates low, and the frequent policymaker turnover orchestrated by the government to enforce this, led to the Taylor principle not being satisfied and eventually a negative coefficient on inflation in the policy rule. In such an environment, was the exchange rate still a random walk? Was inflation anchored? Does the "standard model" suffice to explain the broad contours of macroeconomic outcomes in an emerging economy with large identifying variance in the policy rule? There are no surprises for students of open-economy macroeconomics; the answers are no, no, and yes.

This Draft: September 17, 2022
JEL Classification Codes: E02; E31; E52; E58; F31; F41.

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1 Introduction

Identifying changes in monetary policy that are orthogonal to economic fundamentals and tracking the resulting policy effects remains an active area of research as almost all central bank decisions are endogenous to macroeconomic aggregates, be them realized or expected. Deviations from endogenously implied rates tend to be small, often due to policy choices being discrete, changes in committee composition, and the like. These are usually deviations from a stable policy rule, so-called shocks to monetary policy. Turkey provides an unfortunate but clear natural experiment to observe monetary policy in action, given the change in the rule itself to one that did not satisfy the Taylor principle and then to one with a negative coefficient for inflation, based on a belief that high interest rates cause high inflation and therefore interest rates should be reduced for disinflation. We translate this experiment into standard macroeconomic modeling language and use it to test our understanding of the monetary transmission mechanism. It turns out that no deviations from the standard workhorse model are needed for a complete understanding.

The Turkish economy has not done well recently, with the lira losing value rapidly and inflation skyrocketing. Although this looks like a repeat of the 1990s emerging market problems, the mechanisms are different. In particular, this time the driver was not fiscal dominance because these monetary policy choices and their results were experienced at a time of low and stable debt to GDP ratios and favorable borrowing conditions. The poor outcomes observed in Turkey contain lessons for emerging and advanced economies alike on how not to conduct monetary policy. They also verify our canonical understanding of the relationship between policy frameworks, expectation anchoring, exchange rates, and inflation.

Figure 1 shows in its left panel the Turkish lira per US dollar exchange rate and average of other emerging market exchange rates against the dollar. For ease of comparison, 2003:Q1 is normalized to 100. Beginning around 2011, Turkish lira depreciation has sped up compared to the rest of emerging markets. As of September 2021, the lira had depreciated by around 420% compared to 2003, whereas other emerging market currencies depreciated only about 30%. Most of the difference accumulated since 2011.

The right panel of the same figure shows the year-over-year CPI inflation of Turkey compared to the rest of the emerging market economies. Even though Turkey always had a worse inflation problem compared to most other emerging economies, the country managed to decrease inflation to single digits very rapidly after the twin crises of 2001. Until 2011, Turkish inflation moved closely with other emerging markets even though its level was higher than the average of the rest. The divergence has become more visible and more drastic since 2011. While most emerging markets enjoyed steady low inflation or disinflation until recently, the Turkish inflation rate began to creep up strongly. This joint behavior of Turkish exchange rate and inflation compared to the rest of emerging markets is reminiscent of a purchasing power parity (PPP) relationship.

We argue in this paper that domestic factors are responsible for the stark divergence of Turkey from the rest of the emerging market economies. We show that the dynamics of Turkish lira exchange rate and inflation in the past decade can be fully explained by standard theory and well-understood economic principles. One part of theory that is often less well understood is the neo-Fisher effect. We begin with an accessible discussion of why the neo-Fisher effect is better thought of from the lens of a Taylor rule than the Fisher equation, and relate the two. In that regard, this paper can be read in relation to the recent work of Uribe (2022) and Schmitt-Grohe and Uribe (2022), who theoretically and empirically argue that permanently lower interest rates may lower inflation and appreciate the domestic currency, the so-called neo-Fisherian effect. This is in essence the outcome of a credible reduction in the inflation target. The Turkish case shows what happens when sustained cuts in interest rates are not accompanied by expectations of lower steady state inflation. The results are not pretty.

Empirically, after demonstrating the quite obvious point that fiscal dominance was not an issue until quite recently—that the fiscal theory of the price level did not apply—we first establish the fact that a bivariate unobserved components model works very well in analyzing the joint behavior of inflation and exchange rate depreciation (more accurately changes, but it was depreciating for most of the period). The depreciation rate has accelerated over the years, unlike in most other emerging markets, and inflation picked up in tandem. The significant comovement between inflation and exchange rate trends which began around 2011, again suggesting a PPP relationship, is striking as the estimated correlation of shocks to the two trends is unity. It also follows that the bivariate model is a good predictor of changes in exchange rate. Indeed, using inflation, exchange rate forecasting ability surpasses that of a random walk–a rare improvement over the Meese and Rogoff's (1983) finding.

Armed with this result, we focus on governance issues and consequent loose monetary policy as the potential reason behind the trend comovement. We provide suggestive evidence that Turkey started showing signs of weaker overall institutional quality around 2011. As a short- to medium-term consideration, we show that the Central Bank of the Republic of Turkey (CBRT) deviated from the Taylor principle, which can lead to indeterminacy in inflation. We formalize this argument with a standard New Keynesian model where the

Taylor rule coefficients are subject to regime changes. Alternatively, we show that results are similar to a model with an effective *upper* bound (EUB) on the policy rates. Our main conclusion is that well-understood economic principles and theory help fully explain outcomes due to outsized policy changes, as in Turkey.

We conclude with a section containing a series of event studies covering the fall of 2021, when the CBRT lowered interest rates cumulatively by five percentage points while inflation was four times the target, which led the exchange value of the lira to go into a free fall and inflation to spiral up. The fact that these are "as expected" also verifies our canonical understanding.

This paper belongs to a vast open economy macroeconomics literature, explaining exchange rate dynamics with economic fundamentals. First, our analysis of comovement between exchange rate and inflation is intimately related to a strand of the literature on PPP tests, which are surveyed by Froot and Rogoff (1995) and Rogoff (1996) with the latter focusing on the PPP puzzle. Whereas Mark and Sul (2001) find cointegration between exchange rate and monetary fundamentals and PPP fundamentals respectively, Pedroni (2001) find evidence against a strong form of PPP, both based on post-Bretton Woods panels. Taylor and Taylor (2004) provide an updated survey on the debate. On the prediction side, Cheung et al. (2005) show that a PPP based model does not have better predictive performance than a random walk, consistent with the famous finding of Meese and Rogoff (1983) that economic fundamentals have no additional information to forecast exchange rates. This was rationalized by Engel and West (2005) who show that exchange rate follows a near random walk if economic fundamentals themselves follow a near random walk, leading to the finding. Rossi (2013) argues that exchange rate predictability results depend crucially on the choices made by econometricians such as the forecasting model, forecast horizon, sample period, and the predictor.

Our empirical and theoretical analysis also contribute to the literature that studies effects of monetary policy in small open economies. A non-exhaustive list includes Cushman and Zha (1997) and Kim and Roubini (2000) on the empirical side, and Galí and Monacelli (2005) and De Paoli (2009) on the theoretical aspects. This in turn is closely related to the issue of expectations anchoring under alternative policy rules as studied in Galí (2015). Our examination of the CBRT reaction function is in the manner of Bullard and Mitra (2002) and Davig and Leeper (2007) who analyze the Taylor principle and the associated model determinacy issues. Coibion et al. (2012) and Bernanke (2020) are related works that investigate the optimal inflation target in the context of the effective *lower* bound on the short-term policy rate. In our study, we instead focus on the issue of the effective *upper* bound, a situation currently peculiar to Turkey but is consistent with fiscal dominance, an issue increasingly important in many countries.

Finally, our work belongs to the literature that studies the relationship between monetary policy and exchange rate, for instance Engel and West (2004; 2005). Examples of recent contributions are Inoue and Rossi (2019) who examine the effects of conventional and unconventional monetary policy in the US on the exchange rates and Gürkaynak et al. (2021) who study both the euro area and the US.

The paper is structured as follows: Section 2 presents our understanding of the neo-Fisherian effect that will be the frame of reference throughout, also discussing the issues of fiscal dominance and the exogeneity of the shift in the policy rule; Section 3 provides key empirical facts using standard regression models; Section 4 presents a bivariate unobserved component model of changes in exchange rate and inflation; Section 5 investigates the causal mechanism, both empirically and theoretically; Section 6 provides an analysis of fall 2021; and Section 7 concludes.

2 Neo-Fisherian disinflation and the fiscal theory of the price level

The Fisher equation is an identity relating the nominal interest rate or policy rate to the real interest rate and the expected inflation

$$i_t = r_t + E_t \pi_{t+1} \tag{1}$$

which at steady state satisfies

$$\bar{i} = \bar{r} + \bar{\pi}. \tag{2}$$

It is taken to be self-evident that in the long run the real interest rate is determined by the growth rate of output and hence is exogenous to monetary policy. Therefore, a permanently lower interest rate $\bar{i}$, given invariant $\bar{r}$, must lead to a lower $\bar{\pi}$. This is the Fisher effect that implies permanently lower interest rates will eventually, at steady state, lower inflation.

The neo-Fisher effect, in a standard New Keynesian model where fiscal policy is passive, works through the forward looking Phillips curve, where expected future inflation affects current price setting and current inflation. This backward induction implies that current inflation will be lower because future inflation will be lower. This is the neo-Fisher effect.

Studying the short-run implications of such a policy is instructive. The New Keynesian model is closed by a policy rule (or a loss function). A simple Taylor-type rule that will suffice in this context is of the form

$$i_t = \bar{i} + \phi_\pi(\pi_t - \pi_*) + e_t \tag{3}$$

which due to equation (2) is equivalent to

$$i_t = \bar{r} + \bar{\pi} + \phi_\pi(\pi_t - \pi_*) + e_t, \tag{4}$$

where π_* is the inflation target.

Equation (4) is particularly useful in analyzing how the short-run setting of the policy rate as described by the policy rule and the steady state relate to each other. ϕ_π is the policy parameter that relates the setting of the interest rate to inflation, in its deviation from the inflation target. e_t is a mean zero, i.i.d. shock that makes the policy rate deviate from the rule. At steady state, inflation will be at the target, and in the absence of any shocks the nominal interest rate will be set at the sum of the steady state real interest rate and the inflation target.

A basic New Keynesian model is determinate if the Taylor principle is satisfied, which is when $\phi_\pi > 1$. That is, the central bank raises the policy rate by more than the increase in inflation (assuming the initial impulse was an increase in inflation, but the argument is symmetric) so that in the presence of sticky prices the real interest rate also increases and lowers aggregate demand. This is disinflationary and the existence of a unique bounded path back to the steady state can be shown. On the other hand, when $\phi_\pi < 1$ there is indeterminacy, where expectations become self-fulfilling and the return to the steady state is no longer guaranteed. Indeed, unless agents miraculously coordinate on expecting to be back at the steady state, there will be no convergence back to the steady state. This is well-understood and explained clearly in any textbook treatment of the model such as Galí (2015).

We find it very useful to think of the neo-Fisher effect through the lens of equation (4). Imagine that inflation is high and the central bank wishes to lower it using the neo-Fisherian approach. The nominal interest rate, the left-hand side of the equation, will be permanently lower. What must change on the right-hand side? The answer cannot be e_t as consistently being negative violates the mean zero i.i.d shock definition. Implicitly, the neo-Fisherian idea hinges on π_* being lower. A credibly lower inflation target implies a lower steady state inflation rate (equation 2), which through the forward looking structure of the New Keynesian model brings lower inflation today. In this case, the term in the parentheses in equation (4), the deviation of inflation from the target, has not changed so that its effect on the short-run nominal interest rate is the same, but the constant, partly consisting of the inflation target (as steady state inflation will be at target, $\bar{\pi} = \pi_*$), has gone down, consistent with the lower nominal interest rate.

Notice that in this narrative causality runs from having successfully lowered the inflation target and expected inflation with it to lower nominal interest rates. It is indeed possible that a policymaker will signal a commitment to lower inflation by permanently lowering interest rates, this will be credible, and inflation will fall now. But if the signal does not work, the public may not believe that the policymaker will succeed in lowering inflation. In this case, even though the policy rate is kept low, the inflation target that affects expectations does not follow suit. Equation (4) still has to be satisfied in the eyes of the public. It is still the case that e_t cannot always be negative and steady state inflation (the perceived target) is unchanged. What gives? ϕ_π.

The only way the public can square permanently lower interest rates in the face of inflation above the target is if the policy parameter ϕ_π is lower. And if ϕ_π has declined sufficiently (to a level below unity) the economy will face indeterminacy. Where neo-Fisherian disinflation experiments fail, New Keynesian indeterminacy begins.

The discussion above started with the assumption that there is no fiscal dominance, monetary policy does not have to work to satisfy the consolidated budget constraint of the government. If that is not true, then what appears to be monetary policy choices are fiscal policy actions and monetary policy is endogenously being adjusted according to the budget constraint. In this case, it is fiscal policy that dictates monetary decisions and pins down the price level, as in the seminal work of Leeper (1991).

This fiscal theory of the price level argument is important here for two reasons. First, we will present analysis below that will be based on changes in monetary policy in Turkey. If monetary policy was changing due to fiscal pressure, we will be misidentifying the impulse. Second, as discussed by Cochrane (2018), under fiscal dominance and in particular in the presence of long-term government debt, the neo-Fisherian effect has different short-run properties. Thus, it is meaningful to show that the Turkish public finances were doing well on their own and did not require monetary policy assistance at around 2010-2011 when the monetary policy experiment began, and continued to do well for quite sometime after that.

The standard way of showing public finances were in good order and did not need to lean on the central bank is to present acceptable government debt to GDP ratios. Figure 2 shows this for the Turkish case. It is evident that in the aftermath of the Global Financial Crisis, not only government debt to GDP ratio was low, it was also going down–from about 40% in 2010 to about 28% in 2017–not requiring monetary assistance. The run up in debt in the past few years, beginning in 2019 and picking up pace in 2020 is also evident. For our purposes, the consequential point is the low and stable debt to GDP between 2010 and 2018, the focus of our analysis.

A separate question is whether market participants perceived the fiscal balance as being sound and priced debt accordingly. This is best read from Turkish credit default swap (CDS) spreads, the cost of insuring dollar denominated sovereign debt of Turkey. Figure 3 shows the five-year Turkish CDS spread. Broadly, this measure looks similar to debt to GDP with some more variance both because it is measured in higher frequency and because CDS spreads are affected by the international price of risk as well and understandably show variation at the times of the Global Financial Crisis (GFC) and the European Crisis. Despite these, the CDS spread is low (compared to what it was in early 2000s and in the fall of 2021) and quite stable. The Turkish government was able to borrow from domestic and international markets although it chose not to borrow much as the budget deficits were low, and did not pay a large premium.

The market perception of the sustainability of Turkish public finances is also evident in the credit ratings of the country, which were in an upswing from 2010 onwards and culminating in Turkey becoming investment grade. The credit ratings began to be lowered gently in 2016, gaining speed over time, based on political and institutional considerations (discussed below) more than public finances, especially at the beginning.

Overall, when the Turkish monetary policy experiment began in 2010-11, and for most of its life, at least until 2018 and possibly 2021, the public finances were in good shape and monetary policy support was not needed to roll over debt or monetize the existing stock. This then begs the question why the interest rate was so low and the policy reaction to inflation was so weak. The only plausible answer, corroborated by anecdotal evidence and the Central Bank's behavior, is political pressure. Newspapers were full of the prime minister (at the time) complaining about high interest rates and more importantly, as early as 2010, the central bank was using a very unorthodox policy mix to limit the fallout from keeping interest rates lower than the level consistent with its price stability mandate. These policies included using the reserve requirement, increasing the variance of the interbank rate to worsen the risk return trade off, making the interest rate corridor asymmetric with a high upper bound and allowing the effective rate to trade consistently closer to the upper bound, not funding the money market fully at either the policy rate or the upper bound of the corridor and forcing banks to borrow from the discount window at the penalty rate. Some of these were discussed in detail in Gürkaynak et al. (2015). Collectively these show that the Central Bank was aware that the policy stance was too accomodative and was trying to limit the fallout, unsuccessfully. Another important point here therefore is that the central bank changed the definition of the policy rate over the years. In what follows, we use the correct weighted average of various interest rates administered by the central bank as the policy rate to properly measure the policy stance.

The key to the inference we will make in the remainder of this paper is the observation that the political pressure, which culminated in a high turnover for central bank governors and MPC members, was not driven by fiscal considerations, as argued above. The root cause was a combination of political need for growth above potential due to a high frequency of referanda and elections, a misinterpretation of the correlation between inflation and interest rates as causality from interest rates to inflation,[1] and the observation, recent at the time, that the steep interest rate cuts administered by the central bank during the GFC had worked well in stimulating output without causing high inflation. The last point was correct but ignored the obvious fact that stimulative monetary policy during a crisis marked by insufficient demand will lead to different outcomes to one that is used when output is at potential. While very destructive to the country, this is exactly the kind of policy variation that is exogenous to the macroeconomy that allows identification.

3 The non-random walk of exchange rate

We begin our analysis with a focus on the exchange rate, which is notoriously difficult to forecast. Focusing on the exchange value of the lira is useful as the inflation differential between Turkey and the rest of the world had widened significantly thanks to the weak monetary policy, making questions that ultimately hinge on the purchasing power parity easier to answer.

The left panel of Figure 4 plots the quarterly exchange rate from 2003:Q1 to 2021:Q3 in natural logs. The lira has been consistently depreciating in value at least since 2011, with no clear indication of reversal. As shown in the right panel of Figure 4, the percentage change in the exchange rate was highly volatile, with the quarter-over-quarter change ranging from -19% to 28%.[2]

To analyze exchange rate dynamics, the baseline is to model the exchange rate as a random walk with drift,

$$\triangle s_t = \mu + \epsilon_t \tag{5}$$

where Δs_t is the quarterly log change in the exchange rate at time t, μ is the (possibly zero) intercept, and ϵ_t is an i.i.d. error term. As surveyed in Rossi (2013), random walk specifications for exchange rates serve as benchmarks because of their success in forecasting,

[1] In that regard, Turkey was undertaking the neo-Fisherian experiment before the term was coined. A newspaper column written by one of the economic advisers of the president pointed to the neo-Fisherian literature that was nascent in 2018, arguing that this was what the president was pushing for all along and that lesser economists were unable to comprehend the theoretical subtleties (Ertem, 2018).

[2] The Augmented Dickey-Fuller (ADF) tests and the Phillips-Perron (PP) tests indicate that the log-level of the Turkish lira was integrated of order 1.

especially at short horizons.

Modeling exchange rates as a random walk process has theoretical underpinnings as well. In a standard two-country open economy model (for instance, Clarida, Galí, and Gertler, 2002) where both countries' central banks follow optimal discretionary monetary policy, the price levels will be nonstationary, which, through PPP, will lead to a nonstationary exchange rate.

The inspection of the right panel of Figure 4 suggests that the percentage change in the Turkish lira exchange rate has been possibly trending upward in the sample. To be able to accommodate this possibility, we extend equation (5) by allowing a time trend:

$$\triangle s_t = \mu + \beta t + \epsilon_t \tag{6}$$

where βt is the deterministic time trend in changes (that would manifest as a non-linear trend in levels).

The results based on these models (labeled by their equation numbers) are provided in Table 1. The trend coefficient β is estimated to be positive and highly statistically significant, thus confirming that the percentage change in the lira exchange rate has been trending upward (depreciating faster) in the sample period considered. The exchange rate has not behaved as a random walk in Turkey over the last two decades with the depreciation accelerating over time.

Is the empirical fact documented above particular to Turkey? To answer this question, the models in equations (5) and (6) are estimated using the exchange rates of other emerging market countries (all defined as the value of one dollar in the local currency as in the case of the Turkish lira above) using the same sample period and frequency. For comparability, the selection comprises countries whose (a) exchange rate regime is floating and (b) monetary policy framework is inflation targeting. To this end, the following 10 countries are chosen: Brazil, Colombia, Indonesia, Korea, Mexico, Paraguay, Peru, the Philippines, South Africa, and Thailand.[3]

Table 2 provides the estimate of β in equation (6) for these countries (estimates are multiplied by 100 to ease comparison). Turkey clearly has the largest estimate of β, with some Latin American countries in the sample also being characterized by statistically significant acceleration of the currency depreciation over the last two decades, but not nearly to the same extent as Turkey. For all other countries, the random walk models turn out to be appropriate in the class of models considered.

The regression models considered above, however useful as summary devices in showing

[3]The ADF test and the PP test confirm that the logarithms of their exchange rate series are also integrated of order 1.

basic properties of exchange rates, are restrictive because they consider the exchange rate in isolation and their intercept and trend are constrained to be deterministic. In the following section, we turn to a more general model that relaxes these restrictions.

4 A bivariate unobserved component model

A univariate unobserved components (UC) model (Harvey, 1989), relegated to Appendix A in the interest of space, shows that the exchange rate in Turkey had a predictable trend component and the trend was increasing over time. It also shows that among emerging countries comparable to Turkey, only Brazil and Peru continue to show similar behavior, an issue we discuss further below. In this section, we jointly study inflation and the exchange rate using a bivariate UC model. Theoretically, nominal exchange rate affects domestic inflation via exchange rate pass through, which is important for inflation levels in Turkey (Kara and Sarıkaya, 2021). Conversely, higher inflation rates feed into the nominal exchange rate through relative PPP.

The bivariate UC model that allows feedback between inflation and the exchange rate is

$$\begin{bmatrix} \triangle s_t \\ \pi_t \end{bmatrix} = \begin{bmatrix} \mu_t^{\triangle s} \\ \mu_t^{\pi} \end{bmatrix} + \begin{bmatrix} \epsilon_t^{\triangle s} \\ \epsilon_t^{\pi} \end{bmatrix} \tag{7}$$

$$\begin{bmatrix} \mu_t^{\triangle s} \\ \mu_t^{\pi} \end{bmatrix} = \begin{bmatrix} \mu_{t-1}^{\triangle s} \\ \mu_{t-1}^{\pi} \end{bmatrix} + \begin{bmatrix} \beta_{t-1}^{\triangle s} \\ \beta_{t-1}^{\pi} \end{bmatrix} + \begin{bmatrix} \eta_t^{\triangle s} \\ \eta_t^{\pi} \end{bmatrix} \tag{8}$$

$$\begin{bmatrix} \beta_t^{\triangle s} \\ \beta_t^{\pi} \end{bmatrix} = \begin{bmatrix} \beta_{t-1}^{\triangle s} \\ \beta_{t-1}^{\pi} \end{bmatrix} + \begin{bmatrix} \zeta_t^{\triangle s} \\ \zeta_t^{\pi} \end{bmatrix} \tag{9}$$

where

$$\begin{bmatrix} \epsilon_t^{\triangle s} \\ \epsilon_t^{\pi} \end{bmatrix} \overset{iid}{\sim} N(0, \varSigma_\epsilon), \quad \begin{bmatrix} \eta_t^{\triangle s} \\ \eta_t^{\pi} \end{bmatrix} \overset{iid}{\sim} N(0, \varSigma_\eta), \text{ and } \begin{bmatrix} \zeta_t^{\triangle s} \\ \zeta_t^{\pi} \end{bmatrix} \overset{iid}{\sim} N(0, \varSigma_\zeta)$$

and

$$\varSigma_\epsilon = \begin{bmatrix} \sigma^2_{\epsilon,\triangle s} & \sigma_{\epsilon,\triangle s\pi} \\ \sigma_{\epsilon,\pi\triangle s} & \sigma^2_{\epsilon,\pi} \end{bmatrix}, \ \varSigma_\eta = \begin{bmatrix} \sigma^2_{\eta,\triangle s} & \sigma_{\eta,\triangle s\pi} \\ \sigma_{\eta,\pi\triangle s} & \sigma^2_{\eta,\pi} \end{bmatrix}, \text{ and } \varSigma_\zeta = \begin{bmatrix} \sigma^2_{\zeta,\triangle s} & \sigma_{\zeta,\triangle s\pi} \\ \sigma_{\zeta,\pi\triangle s} & \sigma^2_{\zeta,\pi} \end{bmatrix}.$$

In this specification, the exchange rate and inflation may be correlated depending on the estimates of the covariances in the shock processes. The model is estimated by the maximum likelihood (ML), again for the sample period of 2003:Q1 to 2021:Q3. Table 3 provides parameter estimates. They show that the trend component $\mu_t^{\triangle s}$ is slow-moving.

However, μ_t^π is found to be relatively fast-moving, implying the possibility that the percentage change in the exchange rate and the inflation rate may diverge at times. The correlation between $\epsilon_t^{\triangle s}$ and ϵ_t^π is 0.3 and the correlation between $\eta_t^{\triangle s}$ and η_t^π and between $\zeta_t^{\triangle s}$ and ζ_t^π are practically one, all of which are highly significantly different from zero according to the Pearson correlation test. The key finding therefore is that innovations to both trend components are driven by a common source.[4]

This is a point worth emphasizing: inflation and depreciation of the currency share a common trend. Although we allowed for two separate shocks to the trends of inflation and the change in the exchange rate, the data ask for a single shock to the two series. This is not a statement about causality, but it is a strong statement about PPP as this indicates that the two series are cointegrated at zero frequency (Stock and Watson, 1988).

The Kalman smoothed estimates of $\mu_t^{\triangle s}$ and μ_t^π are presented in Figure 5. Much like the exchange rate depreciation, the inflation rate has been accelerating over the years, with the trend inflation reaching 16% as of 2021. The figure also shows that the two trend components started to comove closely around 2011.[5] The findings so far inevitably lead to the question of what might be behind the comovement of the trends, which is taken up in the next section. Given the extent by which the CBRT has deviated from the Taylor principle, the inflationary spiral should not be surprising. This issue is formally examined in Section 5.4.

Of independent interest is whether the UC models outperform autoregressive forecasting models for the exchange rate in a horse race, in the spirit of Meese and Rogoff (1983). The Diebold-Mariano test shows that they do.[6] Figure 6 shows that while the forecast errors are close, the UC models have the edge, the random walk forecast is beaten. We see that the large variation in the exchange rate stemming from Turkish policy provides identifying variation suitable for testing various important hypotheses, including those about the behavior of exchange rates.

5 Drivers of exchange rate and inflation

Given the empirical results in the previous section, the next step is to analyze further the reasons behind the persistent increase in exchange rate trend and its comovement with the inflation trend. We tackle this question from two angles. First, we show that deterioration in

[4] The autocorrelation functions of the estimated irregular components $\epsilon_t^{\triangle s}$ and ϵ_t^π indicate that the white noise assumption is validated.

[5] The results are robust to using core CPI instead of headline CPI.

[6] We consider a random walk model with and without drift in Section 3, the univariate UC model in Appendix A, and the bivariate model in this section as in Figure 6. Both UC models outperform both random walk models. The detailed information is available in the replication package.

institutional quality is correlated with the deterioration in macroeconomic outcomes. Next, we investigate the effects of Turkish monetary policy on inflation and exchange rate trends and their comovement observed in the data, both empirically and theoretically. We show that Turkey's domestic fundamentals play the key role in exchange rate and inflation dynamics and that those dynamics follow the predictions of current baseline macroeconomic models.

5.1 Institutions: the medium to long-run

In this subsection we investigate the effects of institutional quality at different frequencies. We first focus on the medium to long-run frequency, leaving the analysis at higher frequency to the next subsection. We employ two sets of indicators to investigate the effects in the medium to long run. The first is the worldwide governance indicators (WGI) of the World Bank, which ranks countries in six dimensions: "Control of Corruption", "Government Effectiveness", "Political Stability and Absence of Violence/Terrorism", "Regulatory Quality", "Rule of Law", and "Voice and Accountability."[7] These are available at annual frequency, and cover the sample period from 2003 to 2020. Each indicator gives percentile ranks of countries, with 0 being the lowest rank and 100 being the highest rank. The second is the Economist Intelligence Unit's (EIU) democracy index.[8] This measures the state of democracy across countries, with the score ranging from 0 to 10, with 10 being the fullest democracy. It is available continuously at annual frequency from 2010 onward. Because these indicators are available at annual frequency, the estimated trend components of the percentage change in the Turkish lira exchange rate and inflation rate are converted to annual variables by summing up their values across four quarters of each calendar year.[9]

Figure 7 plots these indicators. Before analyzing the figure, it is useful to note that outcomes such as inflation and exchange rate will lead these measures even when the causality is from governance to monetary policy and market outcomes because pressure on the central bank or proposed new legislation to change the status of independent institutions will be known before they are manifested in forms that are captured by the quantitative measures that rely on central bank governor turnover or legislation on the books.

In Figure 7, a number of variables appear to comove very closely, for instance the trend component of the percentage change in the exchange rate, the trend component of the inflation rate, WGI rule of law, and WGI voice and accountability have similar dynamics. The trend component of the exchange rate is also highly correlated with WGI political stability and absence of violence/terrorism. Even though available on a more limited basis,

[7]Source: https://info.worldbank.org/governance/wgi/

[8]Source: https://www.eiu.com/n/campaigns/democracy-index-2020/

[9]For the inflation rate, the sum is divided by four to reverse the earlier annualization.

the EIU democracy index also comoves with these variables. The correlations of these variables are presented in Table 4, confirming the visual inspection. In light of this result, the findings in Section 3 and Appendix A that Brazil and Peru closely resemble Turkey might not have been a coincidence as these countries also have experienced similar institutional problems at least over the last few years. While Mexico also resembles Brazil and Turkey in some respects, for other countries studied in Section 3, these indices are either improving or declining much less relative to Turkey, Brazil, and Peru. Given that the estimated trends capture slow-moving variations in the exchange rate and the inflation rate, the analysis here is likely picking up the medium to long-run effects of the institutional deterioration, with the policy "response" to political pressure and associated market outcomes leading the measured institutional deterioration.

5.2 Institutions: the short to medium-run

Another useful piece of evidence regarding the effect of institutional decay can be found in the sovereign bond markets, enabling an analysis at higher frequency. Figure 8 presents the yield spreads between the US dollar denominated Turkish government bonds and the US government bonds at various maturities from 2003 to 2020, at annual frequency. Leaving aside the spike in 2008 due to the GFC, the spreads have been generally trending upwards, with the five and ten year bond spreads in excess of four percentage points by the end of 2020. International investors apparently perceive considerable risk in the medium-run, requiring commensurate compensation for holding Turkish bonds. Among drivers of this is institutional weakness. For instance, on June 15, 2019, Moody's downgraded Turkey's long-term debt rating from Ba3 to B1 and commented

> " ... continued erosion in institutional strength and policy effectiveness on investor confidence was outweighing positives such as Turkey's diversified economy and low level of government debt. The inability of political authorities to implement a plan to support the economy remains a key concern."[10]

Table 5 presents Turkey's credit rating history. Since 2016, the major credit rating providers have downgraded Turkey's foreign currency credit ratings multiple times.

In this context, one may consider yield spreads as continuously available measures of sovereign credit rating. To formally verify this, we present regressions of the percentage change in the Turkish lira exchange rate on the change in the yield spread. The model specification assumes that the change in the yield spread is a sufficient statistic encompassing

[10] https://www.ft.com/content/7199c006-8ee6-11e9-a1c1-51bf8f989972

a wide range of information available at the time. Table 6 shows the results.[11] It is interesting to observe that the percentage change in the exchange rate is not statistically significantly related to the current change in the yield of US government bond in almost any cases, but very significantly related to the current change in the yield spread in all cases, even after controlling for relevant macroeconomic fundamentals such as the lagged changes in the Turkish current account balance, the Turkish inflation rate, and the world commodity prices. The analysis based on the CDS spread, which measures the market participants' assessment of the default probability more directly, further confirms that the yield spread is driven by the sovereign risk of Turkey. While the CDS spread is a cleaner measure of the default risk than the bond yield spread, the latter assets have the advantage of being traded more frequently.[12]

A related exercise that can be helpful for thinking about this issue is how much of the change in the bond yields as well as their spreads are driven by the US monetary policy. To this end, high frequency identified monetary policy surprises of Gürkaynak et al. (2005b) (GSS) are employed. These are market-based surprise changes to the federal funds rate target and forward guidance, which are referred to as target and path surprises respectively. To make them compatible with the quarterly exchange rate and bond yield data, they are cumulated within each quarter to arrive at quarterly measures of target and path surprises.

Table 7 shows that whereas both target and path surprises have positive and statistically significant effects on the change in the five year US bond yield, only the target surprise has a statistically significant effect on the change in the yield spread, with a negative sign. This is due to the GFC of 2008 during which the short policy rate of the Fed unexpectedly entered the zero lower bound (ZLB) (with a negative target surprise that is large in magnitude) while the global risk premium soared as a result of the crisis (see Figure 8). In various sub-samples that start after 2008, this result disappears. For instance, in the sub-sample that starts from 2010:Q1, the change in the yield spread does not react to the US monetary policy surprises, which supports the argument that the domestic factors in Turkey are responsible for the movement of the yield spread. Similar results are obtained when the yield spread is replaced by the CDS spread.

Another test that exploits asset price characteristics of the exchange rate is the Granger causality test performed by Engel and West (2005) to examine whether the exchange rate helps forecast fundamentals. Engel and West show that even when there is a meaningful economic relationship between the exchange rate and the fundamentals, it is possible for

[11] Note that this is not a test of an interest rate parity condition because both bonds are issued in the US dollar.

[12] An additional analysis based on state-space models with time varying coefficients confirms robustness of these results.

the exchange rate to behave as a near random walk if the fundamentals are nonstationary themselves. Their finding is relevant here because the measures of institutional quality as well as the bond yield spreads exhibit time trends as shown above. As they argue, if the exchange rate is indeed the present value of the current and expected future fundamentals, then the exchange rate should Granger-cause the fundamentals when the latter are observable. Having shown that the yield spread is driven by Turkish fundamentals, we treat the spread as a quarterly measure of fundamentals and ask whether the exchange rate and the yield spread Granger-cause each other. The results in Table 8 confirm that the exchange rate Granger-causes the fundamentals but not the other way around, verifying the Engel-West conjecture and showing that standard no-arbitrage frameworks help understand the outsized movements in the lira exchange rate.

The key takeaway here is that it is not global factors, such as commodity prices or US monetary policy stance that has primarily driven the lira exchange rate (and inflation, remembering that they share a common trend) but domestic factors manifesting themselves in the decline of institutional quality.

5.3 Monetary policy: empirics

The monetary policy stance is the obvious place to look when the object of interest is strong movements in the exchange rate and inflation. There is a vast literature that studies the relationship between exchange rate and monetary policy, for instance Engel and West (2006) and Molodtsova and Papell (2012) who use a Taylor rule based approach, Rogers et al. (2014) and Gürkaynak et al. (2021) who conduct event studies using high frequency identified monetary policy surprises, and Inoue and Rossi (2019) who use the functional VAR approach. A well-known result from this literature is that violation of the Taylor principle results in indeterminacy, leading to an inflationary spiral and exchange rate depreciation, which can shed light on the observed comovement between inflation and exchange rate trends in Turkey as well.[13] While this is well understood theoretically, episodes where the Taylor principle is not satisfied are rare, especially in recent times. Turkey provides an unfortunate example to test the model predictions. The issue is first examined empirically in this subsection and then theoretically in a framework of an effective upper bound on interest rates in the following subsection.

First, we estimate a Taylor rule with time varying parameters to characterize the mone-

[13] Indeterminacy may also lead to a deflationary spiral but requires a negative shock or focal point, while policy shocks in Turkey were inflationary. We therefore focus on the inflationary spiral, which was the observed outcome.

tary policy stance in Turkey:

$$i_t = r_t + \bar{\pi}_t + \phi_{\pi,t}(\pi_t - \bar{\pi}_t) + \phi_{y,t} y_t + \vartheta_t \tag{10}$$

$$r_t = r_{t-1} + \xi_t \tag{11}$$

$$\phi_{\pi,t} = \phi_{\pi,t-1} + \varrho_t \tag{12}$$

$$\phi_{y,t} = \phi_{y,t-1} + \tau_t \tag{13}$$

where i_t is the policy rate of the central bank, r_t is the (long-run) real rate of interest, $\bar{\pi}_t$ is the time varying inflation target, π_t is the inflation rate, and y_t is a measure of output growth. This equation is estimated via ML for two samples, one from January 2002 to August 2021 and the other from January 2011 to August 2021, both at monthly frequency, to make sure that the results are robust to the transition in the policy rate over time. The policy parameters are $\phi_{\pi,t}$ and $\phi_{y,t}$, which are stochastic processes. Similar to the previous specifications, $\vartheta_t \overset{iid}{\sim} N(0, \sigma_\vartheta^2)$, $\xi_t \overset{iid}{\sim} N(0, \sigma_\xi^2)$, $\varrho_t \overset{iid}{\sim} N(0, \sigma_\varrho^2)$, and $\tau_t \overset{iid}{\sim} N(0, \sigma_\tau^2)$. The policy rate switched from the overnight borrowing rate to the weighted average cost of CBRT funding in 2011.[14] The inflation target is obtained from the CBRT.[15] The inflation is the year-over-year change in the logarithm of the CPI, and y_t is the year-over-year change in the logarithm of the seasonally adjusted industrial production.[16]

Figure 9 provides the results for the longer sample going back to 2002. Clearly, the null hypothesis that the policy parameter $\phi_{\pi,t}$ is at least unity cannot be rejected in the earlier sample but the parameter becomes less than one, not satisfying the Taylor principle, at about 2010 and statistically insignificant (not even different from zero, let alone greater than one) soon after. The finding that the Taylor principle was satisfied and inflation was under control in the early post-2001 period accords with the narrative about the time. Including the earlier period is helpful as it shows that the low parameter estimate in the post-2010

[14] As noted before, in this quite amazing period, the CBRT used a mixture of announced policy rate, top end of the interest rate corridor, and the late liquidity window rate to fund banks. This was to avoid raising the policy rate, which would attract the government's ire, while simultaneously raising the effective funding rate to some extent, which the CBRT knew was needed to contain inflation to some degree. The late liquidity window (discount window), in particular, had not been used for cyclical policy purposes before. Some of this is covered in Gürkaynak et al. (2015), but the episode deserves further study for its policy implementation mechanics, other than the overall stance that is covered here.

[15] Its value was 35% in 2002, 20% in 2003, 12% in 2004, 8% in 2005, 5% in 2006, 4% in 2007 and 2008, 7.5% in 2009, 6.5% in 2010, 5.5% in 2011, and has been 5% since 2011.

[16] The results are robust when the slope component is additionally included in (11). The results are also similar when the output gap estimated using the Hodrick-Prescott filter or a local-level model replaces the output growth above. They are not reported in the interest of space. The policy rate, the logarithm of the CPI, and the logarithm of the industrial production are integrated of order 1 according to the ADF test and the PP test.

period is not a mechanical artifact.[17]

Figure 10 provides the same results for the sample starting in 2011 where the policy rate was more uniform.[18] ("Uniform" in being a difficult-to-understand mix of different rates, unlike the "normal" use of the policy rate in the earlier period.) First, the policy parameter for inflation, $\phi_{\pi,t}$, is not statistically significantly different from zero most of the time. Even when it is, it is almost always statistically below unity, which typically leads to the violation of the Taylor principle unless $\phi_{y,t}$ is implausibly large (which is not the case here). Hence, nominal stabilization could not be effectively attained by the central bank, resulting in inflation and exchange rate indeterminacy. The source of the parameter drift away from the determinacy region is in turn the institutional problems discussed previously, manifesting themselves as hampered central bank independence. The fact that $\phi_{\pi,t}$ closely tracks the movement of the policy rate is indicative of the lack of commitment to price stability.[19] Allowing the perceived inflation target to be different from the announced target does not change this finding, as shown in Appendix B.

We therefore empirically conclude that monetary policy was not stabilizing in this period. We will show theoretically that this is consistent with accelerating inflation.

5.4 Monetary policy: theory

We complement the empirical findings in the previous subsection with a theoretical analysis based on a dynamic stochastic general equilibrium model (DSGE) in this subsection. The following regime-switching New Keynesian (NK) model includes the basic ingredients required for the analysis:[20]

$$x_t = E_t x_{t+1} - \frac{1}{\sigma}(i_t - E_t \pi_{t+1}) + u_t^x \tag{14}$$

$$\pi_t = \beta E_t \pi_{t+1} + \kappa x_t + u_t^\pi \tag{15}$$

$$i_t = (\phi_t^x - \psi^x \triangle_t) x_t + (\phi_t^\pi - \psi^\pi \triangle_t)\pi_t + u_t^i \tag{16}$$

$$\phi_t^x = (1 - \rho_{\phi^x})\phi^x + \rho_{\phi^x}\phi_{t-1}^x + e_t^{\phi^x}, \; e_t^{\phi^x} \overset{iid}{\sim} N(0, \sigma_{\phi^x}^2) \tag{17}$$

[17] The maximized log-likelihood is 907.629. The parameter estimates are $\sigma_\vartheta = 7.505\text{E-}6$, $\sigma_\xi = 0.010$, $\sigma_\varrho = 0.074$, and $\sigma_\tau = 0.002$.

[18] The maximized log-likelihood is 498.788. The parameter estimates are $\sigma_\vartheta = 3.556\text{E-}6$, $\sigma_\xi = 0.007$, $\sigma_\varrho = 0.125$, and $\sigma_\tau = 4.487\text{E-}7$.

[19] Romelli (2022) provides a nice discussion of the political economy of central bank independence and when reforms are undertaken. His finding that reforms often follow periods of high inflation has a flip side here, with reasonably low inflation followed by a loss of central bank independence.

[20] The model becomes isomorphic to an open economy NK model with minor modifications. See Clarida, Galí, and Gertler (2001).

$$\phi_t^\pi = (1-\rho_{\phi^\pi})\phi^\pi + \rho_{\phi^\pi}\phi_{t-1}^\pi + e_t^{\phi^\pi},\ e_t^{\phi^\pi} \overset{iid}{\sim} N(0,\sigma_{\phi^\pi}^2) \tag{18}$$

$$u_t^x = \rho_{u^x} u_{t-1}^x + e_t^{u^x},\ e_t^{u^x} \overset{iid}{\sim} N(0,\sigma_{u^x}^2) \tag{19}$$

$$u_t^\pi = \rho_{u^\pi} u_{t-1}^\pi + e_t^{u^\pi},\ e_t^{u^\pi} \overset{iid}{\sim} N(0,\sigma_{u^\pi}^2) \tag{20}$$

$$u_t^i = \rho_{u^i} u_{t-1}^i + e_t^{u^i},\ e_t^{u^i} \overset{iid}{\sim} N(0,\sigma_{u^i}^2). \tag{21}$$

Equation (14) is the IS equation, equation (15) the New Keynesian Phillips curve (NKPC), and equation (16) the Taylor rule with time-varying policy parameters, which parallels the empirical model in equation (10). x_t is the output gap, π_t is the inflation rate, i_t is the central bank policy rate as deviation from the steady state value, ϕ_t's are time-varying monetary policy parameters which follow autoregressive processes of order 1 (AR(1)), and u_t's are shocks to the output gap, the inflation rate, and the policy rate which also follow AR(1) processes. σ is the inverse of the elasticity of intertemporal substitution, β is the time discount factor, and κ is the slope of the NKPC.

The model is very standard up to the specification of the policy response to inflation, which is regime switching. The regime indicator $\triangle_t$ takes the value of 0 for the normal regime where monetary policy satisfies the Taylor principle and 1 for the weak policy regime where it is hampered for the duration of the regime, following a first order Markov chain

$$\Pi = \begin{bmatrix} \pi_{00} & 1-\pi_{00} \\ 1-\pi_{11} & \pi_{11} \end{bmatrix}. \tag{22}$$

The model by design captures both continuous and fast-moving monetary policy rule changes through ϕ_t^x and ϕ_t^π and discrete and lower-frequency regime changes through $\psi^x\triangle_t$ and $\psi^\pi\triangle_t$, with the latter parameterized to approximate a sudden large shock to the Taylor principle. The use of exogenous regime changes is appropriate in the context of Turkey where policy changes have been largely driven by factors beyond economic considerations. The model is solved at the third order by the Taylor approximation method of Levintal (2018). Even though the weak policy regime, where the inflation parameter ϕ_t^π in equation (16) is reduced by ψ^π, is parameterized so that it is indeterminate by itself, the overall model solution can be determinate if either the normal regime is sufficiently persistent and/or monetary policy strongly pursues the Taylor principle in the normal regime, as shown by Davig and Leeper (2007) in a related context.[21]

[21] The parameter values are set at the standard values used in the literature, which help illustrate the point but are not calibrated for the Turkish economy: $\sigma = 1$, $\beta = 0.99$, $\kappa = 0.1717$, $\phi^x = 0.5$, $\phi^\pi = 1.5$, $\psi^x = 0$, $\psi^\pi = 0.75$, $\rho_{\phi^x} = \rho_{\phi^\pi} = 0.99$, $\rho_{u^x} = \rho_{u^\pi} = \rho_{u^i} = 0.95$, $\sigma_{\phi^x} = \sigma_{\phi^\pi} = \sigma_{u^x} = \sigma_{u^\pi} = \sigma_{u^i} = 0.005$, $\pi_{00} = 0.95$, and $\pi_{11} = 0.9$. The first five are standard values in the literature. ρ_{ϕ^x} and ρ_{ϕ^π} are set close to one to be consistent with the empirical model in equation (10), but simulation results are not sensitive to

Let us consider the following numerical experiment. The model starts from its stochastic steady state under the normal regime ($\triangle_0 = 0$). In the first period, either of the two scenarios takes place: in one, one standard deviation negative shock to the inflation parameter ϕ_1^π occurs ($e_1^{\phi^\pi} = -\sigma_{\phi^\pi}$), and in the other the policy regime switches to the weak policy regime ($\triangle_1 = 1$), where ϕ_1^π decreases from 1.5 to 0.75, and remains so until the end period of the numerical experiment. In the second period, a one standard deviation positive shock to the inflation rate ($e_2^{u^\pi} = \sigma_{u^\pi}$) takes place under both scenarios. Form the third period onward, there is no further shock. The exercise compares how the model economy responds to an inflationary shock over time when it is preceded by different types of regime shocks, one continuous and one discrete (Markov switch).

Figure 11 shows that inflation responds significantly more to the shock under the second scenario. The excessive inflation response is robust to different parameterizations of the model, for instance if π_{11} is decreased from 0.9 that is used for Figure 11 to 0.7 so that the weak policy regime is less persistent. This is shown in Figure 12. These illustrate how exogenous shifts to the policy stance that push the economy into the short-run violation of the Taylor principle can lead to price instability. The findings in the previous subsection indicate that Turkey has been operating under the second scenario over the last decade, and we see here that this results in excessive inflation, as observed in the data. Although not explicitly modeled here, in any framework where PPP exerts some influence the exchange rate will also jump up, and will jump before the full inflation effect is realized due to arbitrage under rational expectations.

Another useful way to think about the violation of the Taylor principle is to consider a setting where the economy faces an occasionally binding effective upper bound (EUB) on the policy rate, for example for political reasons, as in Turkey. The effect of a lower bound (ELB) is well understood and the problem it causes in fighting deflation has led to a deep body of work, beginning with Krugman (1998) and Eggertsson and Woodford (2003). The effective upper bound (for the record, we are not thrilled to be coining this term in the context of Turkey) is not due to basic economic mechanisms, in contrast to ELB, but is imposed by political considerations. Turkey provides a clear example but in a world with eroding central bank independence many other countries will likely face similar pressure. The exercise is therefore of general interest. To illustrate the effect of the EUB constraint, it is sufficient to consider a simpler version of the NK model above which consists of equations (14), (15), (19), (20), and the Taylor rule of the form

$$i_t = \min[i^{\text{EUB}}, \phi^x x_t + \phi^\pi \pi_t] \tag{23}$$

this choice.

where i^{EUB} is the effective upper bound on the policy rate. This setting admits a scenario where the Taylor principle is sustained until the policy rate crosses the threshold of i^{EUB}, after which monetary policy is no longer able to further stabilize the economy.

To consider the aforementioned scenario, the policy rate is constrained to have a maximum deviation of five percentage points from its steady state value.[22] To run the simulation, we assume that the economy suddenly faces two standard deviation positive shocks to the output gap and the inflation rate ($e_1^{u^x} = 2\sigma_{u^x}$ and $e_1^{u^\pi} = 2\sigma_{u^\pi}$) in the first period and no shocks thereafter, which make the EUB bind immediately. (A sequence of smaller shocks have similar effects and the paths are the same once the constraint is binding.). Figure 13 presents the results of the experiment. The economy experiences significantly higher output gap and inflation rate under the EUB. This is indeed the flip side of the ELB coin, with inflation being too high rather than too low.

Taken together, the theoretical models above help understand macroeconomic volatility in a country where the central bank is under political pressure to keep interest rates low. The Taylor principle might have been violated in more than one way, but they all seem to lead to excessive inflation in the Turkish case, which ultimately makes the Turkish lira less attractive and depreciate in value. The key observation is that these are very standard models producing expected results through standard, well-understood channels under weak monetary policy rules. These canonical models capture the broad contours of observed dynamics very well.

6 Fall of 2021

Our sample period ends in 2021:Q3. This excludes a fascinating period in the fall of 2021, which would have been an outlier even in the extraordinary sample period we have covered. In this section we narrate the developments until the end of 2021 for completeness and to provide a record of this hopefully unique episode.

The governor of the CBRT was removed from his post in March 2021 and in his place a former member of the parliament from the governing party, who had recently written columns arguing that higher interest rates cause higher inflation, was appointed, making him the fourth governor of the Central Bank in three years. Expectations for a quick rate cut were proven wrong amid inflation (15.6% as known in real time, for February 2021) being substantially above the target (5%). In August 2021, the pressure from the government to reduce interest rates were renewed:

[22]The specific level of the upper bound is inconsequential for the results, as is the level of the steady state interest rate.

> “ ‘No more high interest-rates because high interest rates would bring us higher inflation,’ Erdogan told ... ahead of the central bank’s Aug. 12 rate decision. His second call for a rate cut in as many months ... ‘It is not possible for inflation to accelerate further from now on, because we’re transiting to lower interest rates,’ Erdogan said. ‘I guess I am giving this signal to somewhere,’ he added, without specifying.” (Kozok and Hacaoğlu, 2021)

The lira depreciated 1.3% on the day of this speech. Once again, expectations were for a rate cut despite inflation having risen to 18.95% (as known in real time). In the event, the MPC did not cut rates and issued a defiant statement:

> “Taking into account the high levels of inflation and inflation expectations, the current tight monetary policy stance will be maintained decisively until the significant fall in the Inflation Report’s forecast path is achieved. Accordingly, the MPC has decided to keep the policy rate unchanged.
>
> The CBRT will continue to use decisively all available instruments in pursuit of the primary objective of price stability. The policy rate will continue to be determined at a level above inflation to maintain a strong disinflationary effect until strong indicators point to a permanent fall in inflation and the medium-term 5 percent target is reached.” (CBRT, 2021)

The exchange rate was about unchanged on the day but the lira slowly began to appreciate, with a cumulative appreciation of about 4% by the beginning of September. Despite the previous statement committing to keeping the policy rate above inflation, a 100 bp rate cut came in September 2021, when inflation was 19.25% (again based on the latest released data at the time). The lira began to depreciate rapidly. This was followed by a 200 bp cut in October and two 100 bp cuts in November and December, respectively. In between, two deputy governors of the CBRT were replaced on the 14th of October. The upper panels of Figure 14 show the paths of the policy rate, and the exchange rate on a daily frequency from the beginning of May to the end of the year, with key dates marked. The exchange rate behaved as expected. Although the daily jumps are difficult to see due to the lira depreciating rapidly and the scale hiding daily changes, the cumulative depreciation of the lira from the day before the first rate cut to its nadir on 20 December 2021 was more than 100%. On the days of the November and December policy decisions the lira depreciated by about 3% and 4%, respectively. It is clear that the exchange value of the lira was no longer under control as of November.

This depreciation of the lira continued unabated until the 20th of December when the government announced a new scheme, FX-protected deposits. These promise the higher of an interest rate close to (but possibly above) the policy rate of the CBRT and the percentage change in the dollar exchange rate. The Treasury promises to pay the difference between the ex-ante interest rate and the depreciation of the lira (various schemes in the group have slightly different forms but this is the most common one), making lira deposits enticing again at the expense of future Treasury outlays. Combined with a large Central Bank foreign reserve sale and moral suasion for large depositors, these calmed lira by the end of the year, albeit at a 60% depreciated level compared its value at the beginning of September.[23]

More interesting are the paths interest rates other than the policy rate took. The policy rate, obviously, is an administrative rate and affects only the shortest end of the yield curve in the interbank market. The lower right panel of Figure 14 also shows the yield of the five-year Treasury security and consumer loan rate along with the policy rate. It is remarkable that these longer-term rates were going *up* as the policy rate was being cut time after time. This is quite strong evidence that "wrong" financial market responses to policy are often due to market participants' inference about policy rules and objectives rather than the central bank signaling the state of the economy. These longer-term interest rates were going up because market participants realized that the central bank was not interested in keeping inflation in check, leading to a lower perceived response to inflation in the policy rule and higher perceived steady state inflation. Both of these lead to higher longer-term interest rates (Gürkaynak et al., 2005a; Smith and Taylor, 2009).

Lastly, the lower left panel of Figure 14 plots the path of realized CPI inflation. As expected, inflation has taken off, officially reaching 36% by the end of 2021 and 80% at the time of writing (August 2022). All of these, of course, are as one would expect based on standard macroeconomic principles, discussed in this paper.

7 Conclusion

This paper presents the recent Turkish exchange rate and inflation dynamics in a coherent framework, relating these to monetary policy. It is hopefully a useful reference for researchers interested in Turkey per se. More importantly, the paper presents evidence that some of the calamities the basic New Keynesian model predicts under weak monetary policy actually happen, using the unfortunate monetary policy framework in Turkey as the result of politically induced, identified shock to the policy rule itself. We hope the paper will be a useful teaching tool and will foster more research into monetary policy pathologies.

The textbook New Keynesian model predicts indeterminacy and, in response to inflation-

[23]Readers interested in the effects of such guarantees for bank liabilities may find Burnside et al. (2001) illuminating.

ary shocks, spiraling inflation when monetary policy does not satisfy the Taylor principle (Galí, 2015). Policy rules that fail this test were not easy to find in the recent past, hence whether the world actually blows up under the weak rule was not testable in the data. Turkey, with its very weak policy rule, provides the laboratory to study this case and verifies the canonical theory. It also provides an example of monetary policy that lowers interest rates permanently in the Uribe (2022) and Schmitt-Grohe and Uribe (2022) neo-Fisherian sense but fails to lower expected steady state inflation. The result is out-of-control inflation. Policymakers planning neo-Fisherian disinflations should think twice, lest public public perceptions do not cooperate.

In presenting the theoretical model, we introduce an effective upper bound (EUB), a politically induced upper limit on interest rates, and show that under such a constraint inflation will not be controllable, spiraling up. This is the flip side of the ELB coin, where deflation becomes self-sustaining as the central bank cannot lower rates to inflate once at the lower bound. These are cautionary tales for central bankers of advanced and emerging economies alike as central bank mandates and independence are being discussed around the world amid post-covid reflation.

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Tables and figures

Table 1: Regression models

	Model in eq. (5)	Model in eq. (6)
μ	0.022 **	-0.019 *
	(0.009)	(0.011)
β		0.001 ***
		(0.000)
Adj. R^2	n/a	0.085

The dependent variable is the percentage change in the Turkish lira exchange rate from 2003:Q1 to 2021:Q3. The numbers in the parentheses are the standard errors. The Newey-West standard errors are used to correct for heteroscedasticity and autocorrelation of regression residuals. * stands for $0.05 < p \leq 0.1$, ** $0.01 < p \leq 0.05$, and *** $p \leq 0.01$.

Table 2: The estimate of β across countries

Country	Model in eq. (6)
Brazil	0.106 ***
Colombia	0.063 **
Indonesia	0.007
Korea	0.014
Mexico	0.008
Paraguay	0.059 ***
Peru	0.041 ***
Philippines	0.017
South Africa	0.037
Thailand	0.025
Turkey	0.110 ***

The estimates are multiplied by 100 to facilitate the cross-country comparison. The p-values are computed using the Newey-West standard errors. * stands for $0.05 < p \leq 0.1$, ** $0.01 < p \leq 0.05$, and *** $p \leq 0.01$.

Table 3: The maximized log-likelihood and the estimates of the parameters and the moments

Log-likelihood	$\sigma_{\epsilon,\triangle s}$	$\sigma_{\epsilon,\pi}$	$\sigma_{\epsilon,\triangle s\pi}$	$\sigma_{\eta,\triangle s}$
279.862	0.074	0.058	0.001	4.492E-7
$\sigma_{\eta,\pi}$	$\sigma_{\eta,\triangle s\pi}$	$\sigma_{\zeta,\triangle s}$	$\sigma_{\zeta,\pi}$	$\sigma_{\zeta,\triangle s\pi}$
3.460E-7	1.554E-13	1.509E-10	5.077E-4	7.660E-14
$corr(\epsilon_t^{\triangle s}, \epsilon_t^{\pi})$	$corr(\eta_t^{\triangle s}, \eta_t^{\pi})$	$corr(\zeta_t^{\triangle s}, \zeta_t^{\pi})$		
0.3	1	1		

Table 4: The correlations of the estimated trends and the worldwide governance indicators

	Exchange Rate	Inflation	Ctrl of Corruption	Govt Effectiveness	Political Stability	Regulatory Quality	Rule of Law	Voice
Exchange Rate	1.000							
Inflation	0.623	1.000						
Ctrl of Corruption	-0.593	-0.942	1.000					
Govt Effectiveness	-0.409	-0.864	0.819	1.000				
Political Stability	-0.877	-0.386	0.399	0.225	1.000			
Regulatory Quality	-0.206	-0.789	0.733	0.831	-0.025	1.000		
Rule of Law	-0.826	-0.865	0.795	0.791	0.640	0.600	1.000	
Voice	-0.941	-0.808	0.789	0.616	0.798	0.435	0.926	1.000

Table 5: Turkey's foreign currency credit rating history

	Credit Rating			Credit Rating Scale			
	Fitch	Moody's	S&P	Fitch	Moody's	S&P	Description
2003	B	B1	B+	AAA	Aaa	AAA	Prime
2004	B+		BB-	AA+	Aa1	AA+	
2005	BB-	Ba3		AA	Aa2	AA	High Medium
2006				AA-	Aa3	AA-	
2007				A+	A1	A+	
2008				A	A2	A	Upper Medium
2009	BB+			A-	A3	A-	
2010		Ba2	BB	BBB+	Baa1	BBB+	
2011				BBB	Baa2	BBB	Lower Medium
2012	BBB-	Ba1		BBB-	Baa3	BBB-	
2013		Baa3	BB+	BB+	Ba1	BB+	
2014				BB	Ba2	BB	Speculative
2015				BB-	Ba3	BB-	
2016		Ba1	BB	B+	B1	B+	
2017	BB+			B	B2	B	Highly Speculative
2018	BB	Ba3	B+	B-	B3	B-	
2019	BB-	B1		CCC+	Caa1	CCC+	
2020		B2		CCC	Caa2	CCC	Substantial Risk
2021				CCC-	Caa3	CCC-	

The table shows the last rating announced in each calendar year. The empty entries mean no change from the previous year(s).

Table 6: Regression models with the change in the yield spread and the CDS spread

	Two Yr	Five Yr	Ten Yr	Five Yr	Five Yr^c	Five Yr	Five Yr^c	Five Yr	Five Yr^c	Five Yr	Five Yr^c	Five Yr	Five Yr^c	Five Yr	Five Yr^c
μ	9.443 ***	9.940 ***	9.922 ***	2.633 ***	2.673 ***	-0.383	0.160	-0.178	0.679	-0.362	0.479	-0.365	0.475	-0.097	0.680
	(3.152)	(2.251)	(2.810)	(0.708)	(0.631)	(0.756)	(0.905)	(0.843)	(0.846)	(0.680)	(0.821)	(0.729)	(0.745)	(0.500)	(0.562)
β						0.085 ***	0.071 ***	0.081 ***	0.061 ***	0.086 ***	0.066 ***	0.086 ***	0.066 ***	0.084 ***	0.065 ***
						(0.016)	(0.018)	(0.017)	(0.017)	(0.013)	(0.016)	(0.014)	(0.013)	(0.010)	(0.012)
θ_1	1.577	4.295	3.874 *	1.107	0.382	1.202	0.451	2.306	1.200	2.010	1.037	2.030	1.059	2.048	1.126
	(2.142)	(2.700)	(2.125)	(2.161)	(1.939)	(2.449)	(1.933)	(2.986)	(2.169)	(2.745)	(1.921)	(2.881)	(1.720)	(2.808)	(1.815)
θ_2	3.925 ***	6.165 ***	7.470 ***	3.944 ***	6.290 ***	3.894 ***	6.130 ***	4.664 ***	6.990 ***	4.399 ***	6.743 ***	4.401 ***	6.745 ***	4.375 ***	6.684 ***
	(0.505)	(0.786)	(1.052)	(1.006)	(1.159)	(0.950)	(1.267)	(0.908)	(0.895)	(0.693)	(0.798)	(0.708)	(0.684)	(0.623)	(0.691)
θ_3								1.139	2.084 ***	0.971	1.920 ***	0.970	1.924 **	2.315 **	3.209 ***
								(0.912)	(0.767)	(0.827)	(0.687)	(0.839)	(0.731)	(0.895)	(0.841)
θ_4								2.126 ***	2.427 ***	1.904 ***	2.208 ***	1.891 ***	2.195 ***	1.465 *	1.875 **
								(0.710)	(0.626)	(0.642)	(0.612)	(0.577)	(0.598)	(0.760)	(0.757)
θ_5										-1.183 **	-1.161 **	-1.200 *	-1.178 **	-1.645 ***	-1.547 ***
										(0.590)	(0.492)	(0.654)	(0.459)	(0.319)	(0.282)
θ_6												-0.010	-0.010	-0.007	-0.004
												(0.073)	(0.045)	(0.069)	(0.046)
θ_7														-0.142	-0.124
														(0.089)	(0.097)
Adj. R^2	0.128	0.345	0.387	0.231	0.394	0.276	0.424	0.302	0.462	0.307	0.469	0.296	0.461	0.313	0.475

The regression model:

$$\triangle s_t = \mu + \beta t + \theta_1 \triangle \text{Yield}_t^{\text{US}} + \theta_2(\triangle \text{Yield}_t^{\text{TR,USD}} - \triangle \text{Yield}_t^{\text{US}}) + \theta_3 \triangle \text{Yield}_{t-1}^{\text{US}}$$
$$+\theta_4(\triangle \text{Yield}_{t-1}^{\text{TR,USD}} - \triangle \text{Yield}_{t-1}^{\text{US}}) + \theta_5 \triangle CA_{t-1} + \theta_6 \triangle \pi_{t-1} + \theta_7 \triangle P_{t-1}^{\text{Commodity}} + \epsilon_t$$

where $\triangle \text{Yield}_t^{\text{US}}$ is the change in the yield of the US government bond, $\triangle \text{Yield}_t^{\text{TR,USD}}$ is the change in the yield of the US dollar denominated Turkish government bond, $\triangle CA_t$ is the change in the Turkish current account balance as a percentage of GDP, $\triangle \pi_t$ is the change in the Turkish CPI inflation rate, and $\triangle P_t^{\text{Commodity}}$ is the percentage change in the IMF world commodity price index. The superscript c means that the change in the bond yield spread is replaced by the change in CDS spread in the regression model.

From the second to the fourth columns, the data frequency is annual. The dependent variable is the annual percentage change in the Turkish lira exchange rate from 2004 to 2020. For the remaining columns, the data frequency is quarterly. The dependent variable is the quarterly percentage change in the exchange rate from 2004:Q2 to 2021:Q3 for the first four of these and from 2004:Q3 to 2021:Q3 for the rest of these. Both dependent variables are the first difference of the logarithm of the exchange rate multiplied by 100 to facilitate interpretation. Because of the data limitations for the Turkish government bonds at quarterly frequency, only the yield spread of the five year bonds is considered for the quarterly regression model. This is also the case for the CDS spread (in percentage) which rotates with the yield spread. The deterministic time trend is also examined in the quarterly regression model to make it comparable to the model in equation (6) (divide the coefficients by 100 for the comparison with Table 1). The time trends are highly statistically significant if also included in the annual regression models (not shown for brevity). The CPI inflation rate is the annualized quarter-over-quarter inflation rate. The percentage change in the IMF world commodity price index is the quarter-over-quarter change in the logarithm of the index multiplied by 100. The entries in the first row refer to the maturity of the bonds whose change in the yield, the yield spread, and the CDS spread are employed as the independent variables. The numbers in the parentheses are the Newey-West standard errors. * stands for $0.05 < p \leq 0.1$, ** $0.01 < p \leq 0.05$, and *** $p \leq 0.01$.

Table 7: The effect of the US monetary policy on the bond yields and spreads

	Sample: 2004:Q2 to 2019:Q2			Sample: 2010:Q1 to 2019:Q2		
	$\triangle\text{Yield}_t^{\text{US}}$	$\triangle$Yield Spread$_t$	$\triangle$CDS Spread$_t$	$\triangle\text{Yield}_t^{\text{US}}$	$\triangle$Yield Spread$_t$	$\triangle$CDS Spread$_t$
χ	-0.050	0.097	0.073	0.000	0.182	0.130
	(0.046)	(0.087)	(0.066)	(0.067)	(0.113)	(0.097)
ψ_1	0.212 ***	-0.350 ***	-0.356 ***	-0.017	-0.373	-0.283
	(0.041)	(0.078)	(0.093)	(0.226)	(0.471)	(0.330)
ψ_2	0.107 **	-0.031	0.025	0.169 ***	-0.069	-0.049
	(0.049)	(0.036)	(0.047)	(0.030)	(0.054)	(0.043)
Adj. R^2	0.147	0.060	0.083	0.185	-0.008	-0.021

The regression model:

$$y_t = \chi + \psi_1 \text{target}_t + \psi_2 \text{path}_t + \upsilon_t$$

where y_t corresponds to the variables in the second row. $\triangle$Yield Spread$_t$ is the difference between $\triangle\text{Yield}_t^{\text{TR,USD}}$ and $\triangle\text{Yield}_t^{\text{US}}$ (see Table 6) and $\triangle$CDS Spread$_t$ is the change in the CDS spread. The GSS target and path surprises are cumulated within each quarter to arrive at quarterly measures.

The full sample period is from 2004:Q2 to 2019:Q2. Because of the data limitations, only the yields and spreads of the five year bonds are considered here. The results are robust to the inclusion of the deterministic time trend (not shown in the interest of space). The numbers in the parentheses are the Newey-West standard errors. * stands for $0.05 < p \leq 0.1$, ** $0.01 < p \leq 0.05$, and *** $p \leq 0.01$.

Table 8: Granger causality test

	$m = 6$	$m = 8$	$m = 10$	$m = 12$
H_0: $\triangle s_t$ does not Granger-cause $\triangle$Yield Spread$_t$	3.297 ***	3.488 ***	3.075 ***	2.305 **
H_0: $\triangle$Yield Spread$_t$ does not Granger-cause $\triangle s_t$	0.806	0.853	0.661	0.413

The sample period is from 2004:Q2 to 2021:Q3. Because of the data limitations, only the yield spread of the five year bonds is considered here. The F-tests statistics are reported with their p-values indicated by the number of *. * stands for $0.05 < p \leq 0.1$, ** $0.01 < p \leq 0.05$, and *** $p \leq 0.01$. The test that the bond-yield spread does not Granger-cause the exchange rate is based on the regression model

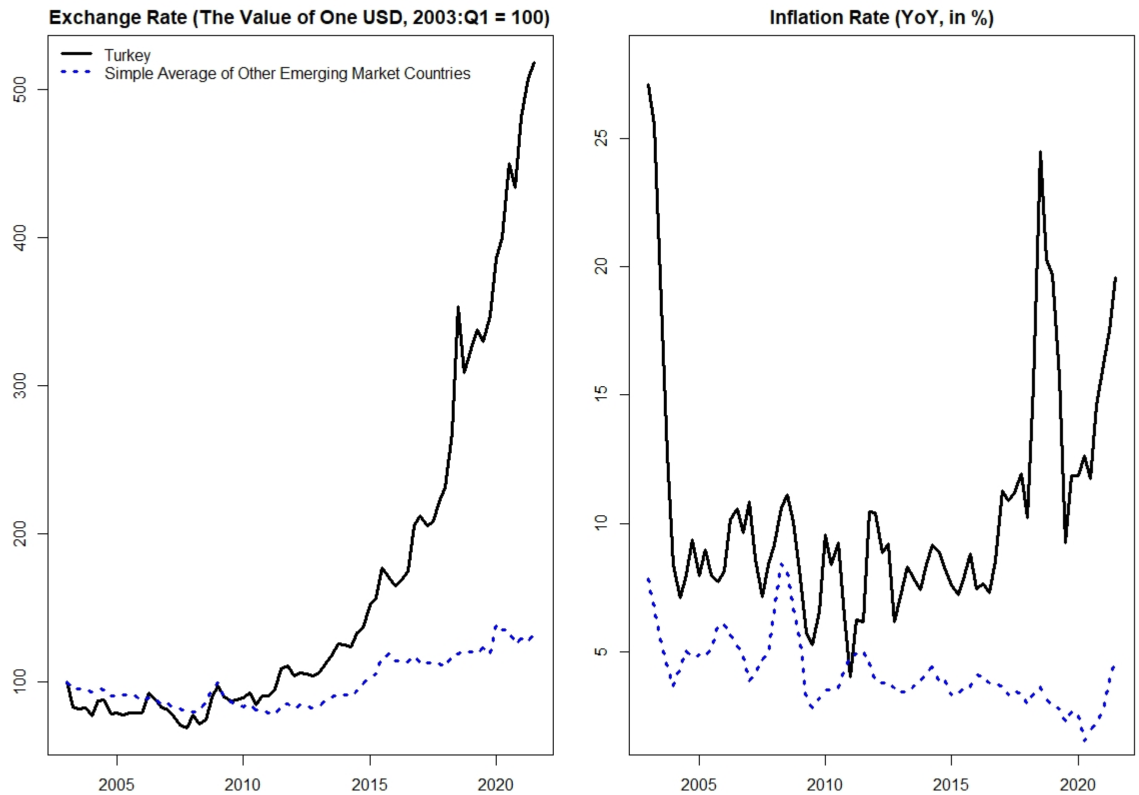
$$\triangle s_t = a_0 + \sum_{i=1}^{m} a_i \triangle s_{t-i} + \sum_{i=1}^{m} b_i \triangle \text{Yield Spread}_{t-i} + \text{error}_t$$

where m is the lag order. The null hypothesis of non-causality takes the form

$$H_0 : b_1 = b_2 = ... = b_m = 0$$

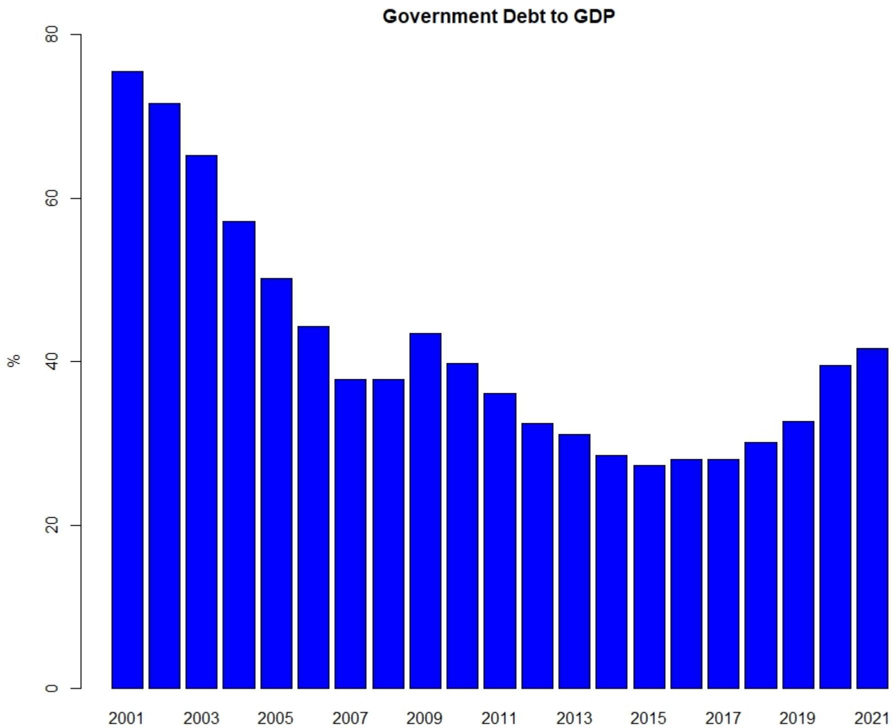
which is the Wald test. For the test in the other direction, the places of $\triangle s_t$ and $\triangle$Yield Spread$_t$ in the regression model above are interchanged.

Figure 1: Exchange rates and inflation rates in Turkey and other emerging market countries



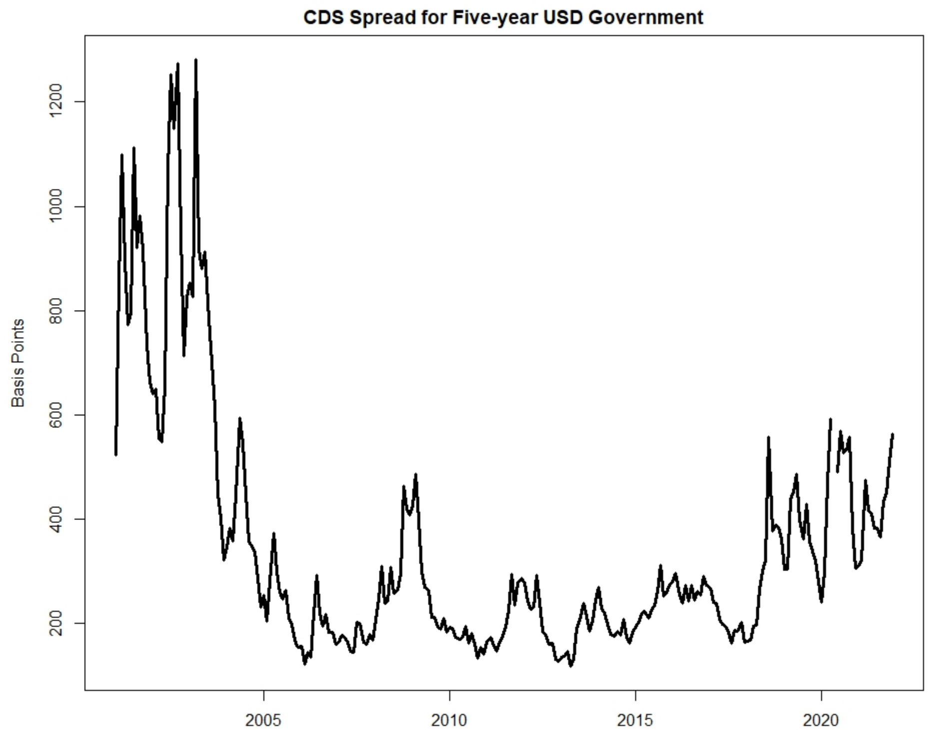
The sample period for the figure is 2003:Q1 to 2021:Q3. The left panel of the figure compares the Turkish lira exchange rate ((black) solid line) to the simple average of the exchange rates of 10 emerging market countries ((blue) dotted line) studied in Section 3, which are Brazil, Colombia, Indonesia, Korea, Mexico, Paraguay, Peru, the Philippines, South Africa, and Thailand. The exchange rate convention is the value of one USD in the local currency unit. For each country, the exchange rate in 2003:Q1 is normalized to 100 for comparability. The right panel compares the year-over-year CPI inflation rate (in %) for these countries.

Figure 2: Turkish government debt to GDP ratio (annual)



Total gross government debt as a fraction of GDP.

Figure 3: Five-year Turkish CDS spread



Credit default swap spreads for US dollar denominated five-year Turkish government securities from January 2001 to December 2021.

Figure 4: USD to TRY (TRY per USD) exchange rate (quarterly)

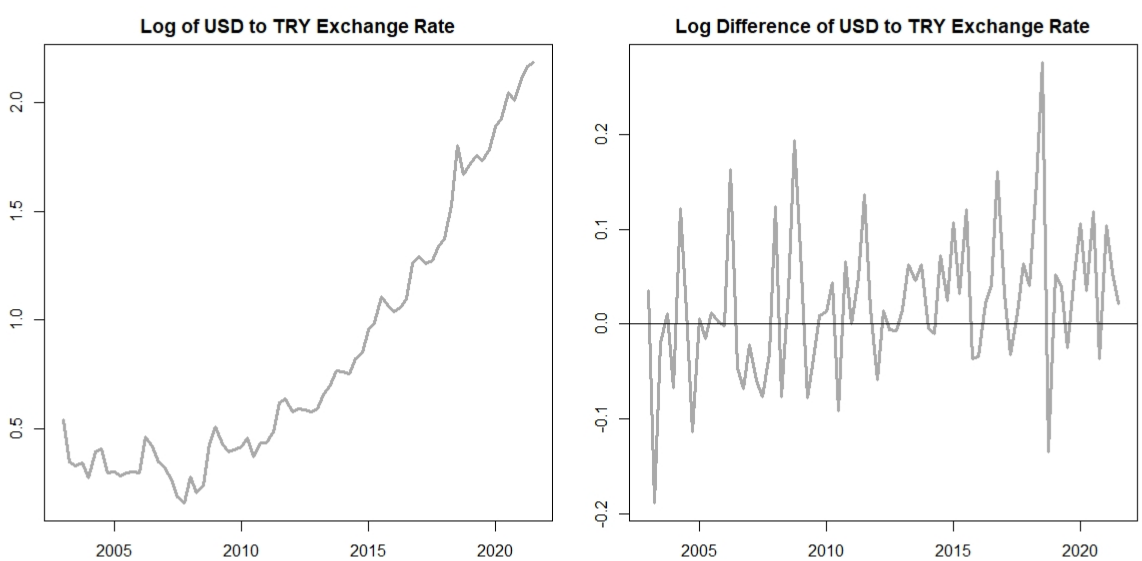
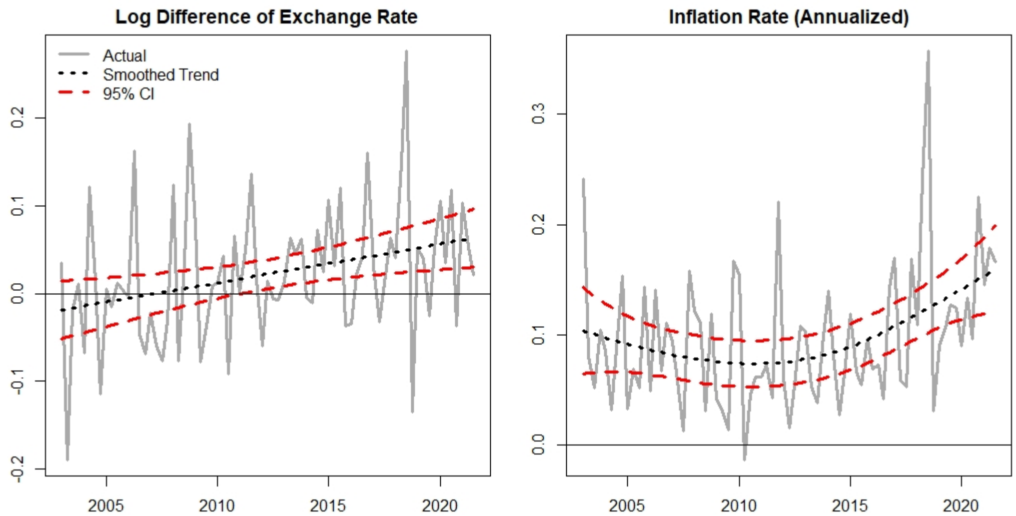
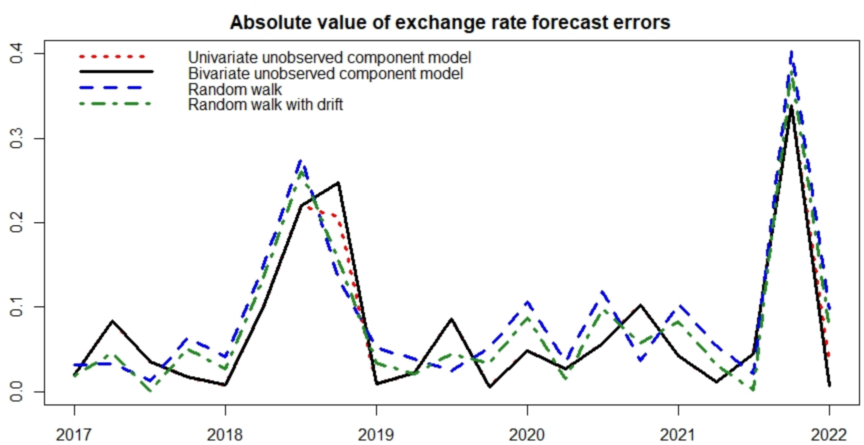


Figure 5: The Kalman smoothed estimates of $\mu_t^{\triangle s}$ and μ_t^{π}



The sample period for the figure is 2003:Q1 to 2021:Q3. The (gray) solid lines show the percentage change in the Turkish lira exchange rate (left) and the annualized quarter-over-quarter inflation rate (right). The (black) dotted lines give the Kalman smoothed estimates of the trend components $\mu_t^{\triangle s}$ and μ_t^{π}. The (red) dashed lines plot the 95% confidence intervals for the trend components.

Figure 6: Out-of-sample forecast errors for various statistical models of exchange rate



The figure plots the absolute values of recursive one-quarter ahead forecast errors for exchange rate for various statistical models from 2017:Q1 onward.

Figure 7: The estimated trends, the worldwide governance indicators, and the democracy index (annual)

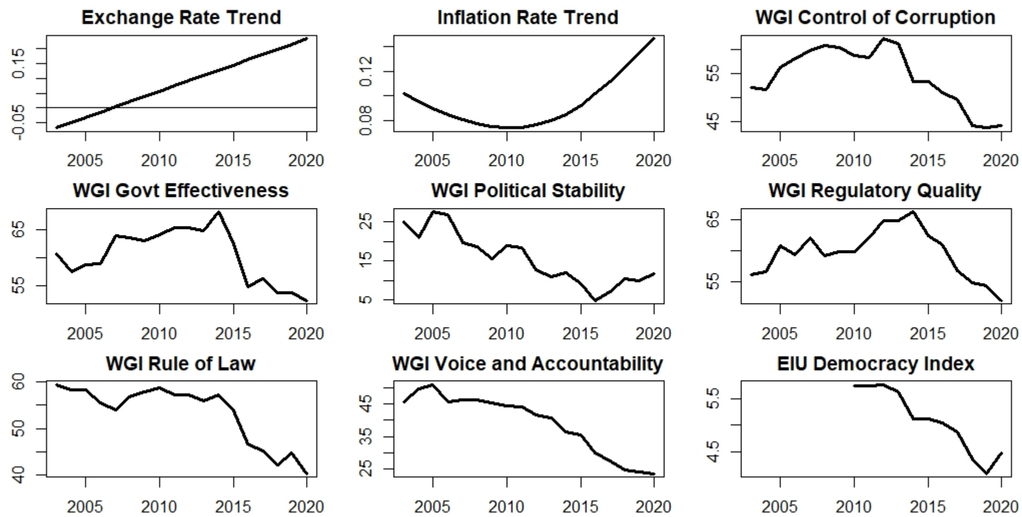
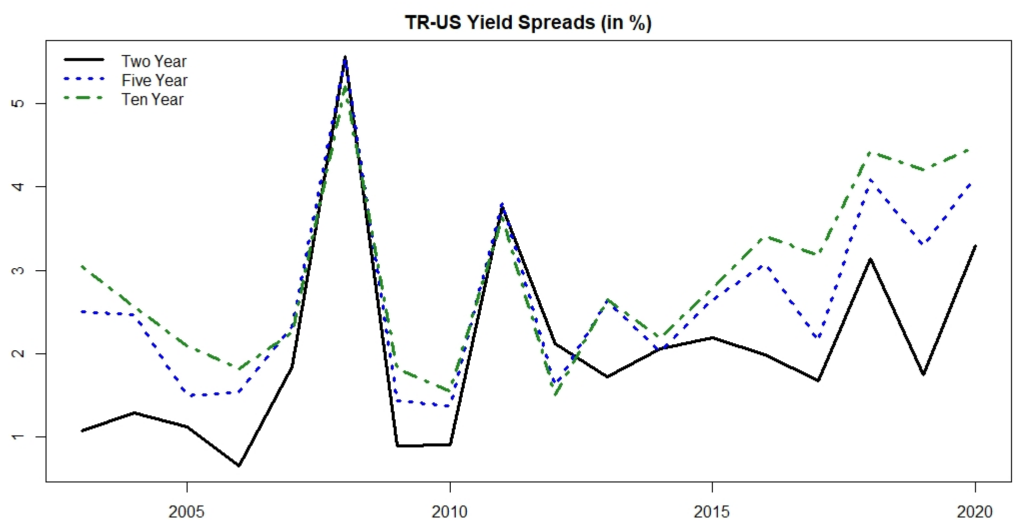
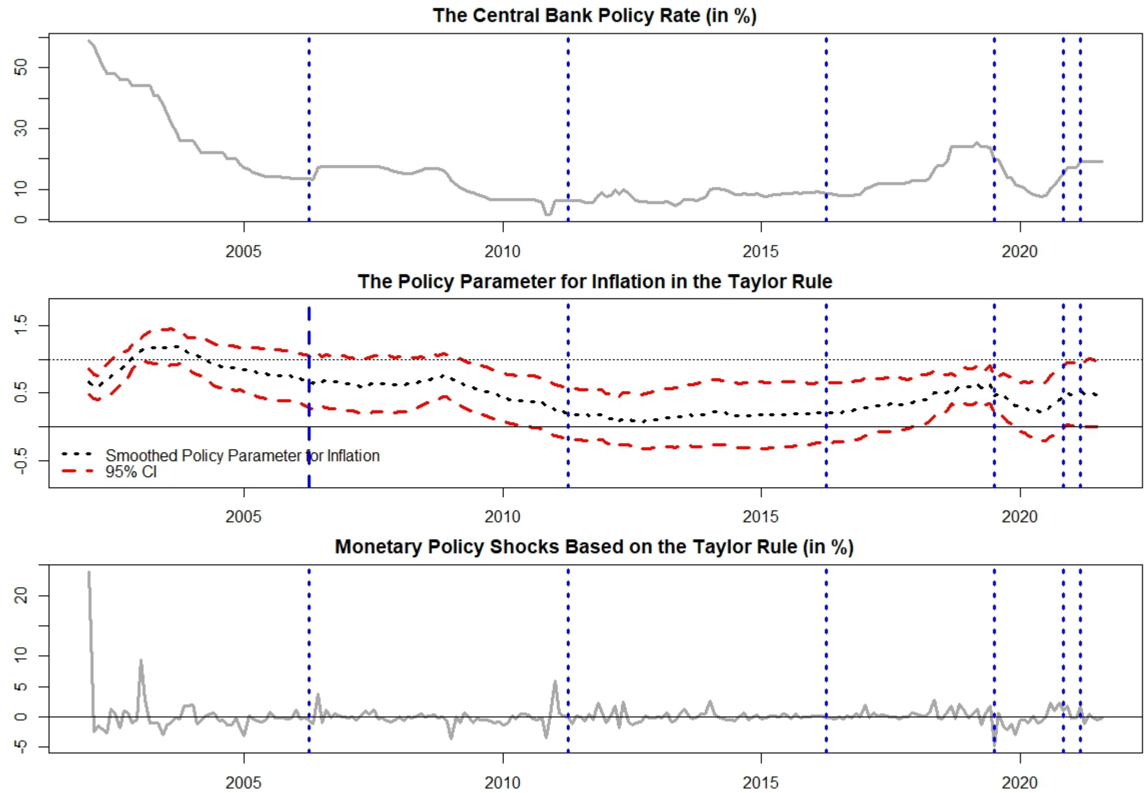


Figure 8: Sovereign yield spreads between Turkey and the US (annual)



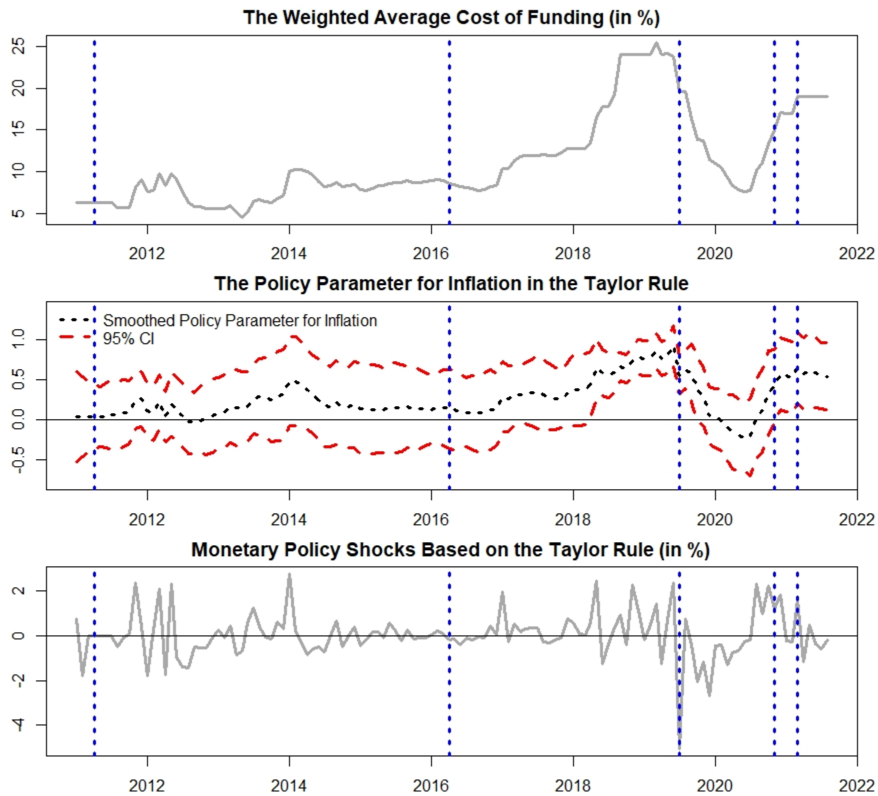
These are the differences between the US dollar denominated Turkish government bond yields and the US government bond yields at various maturities. The (black) solid line is for the two year maturity bonds, the (blue) dotted line for the five year maturity bonds, and the (green) dot dashed line for the ten year maturity bonds. The sample coverage is from 2003 to 2020, at annual frequency.

Figure 9: The Taylor rule with time-varying parameters: longer sample



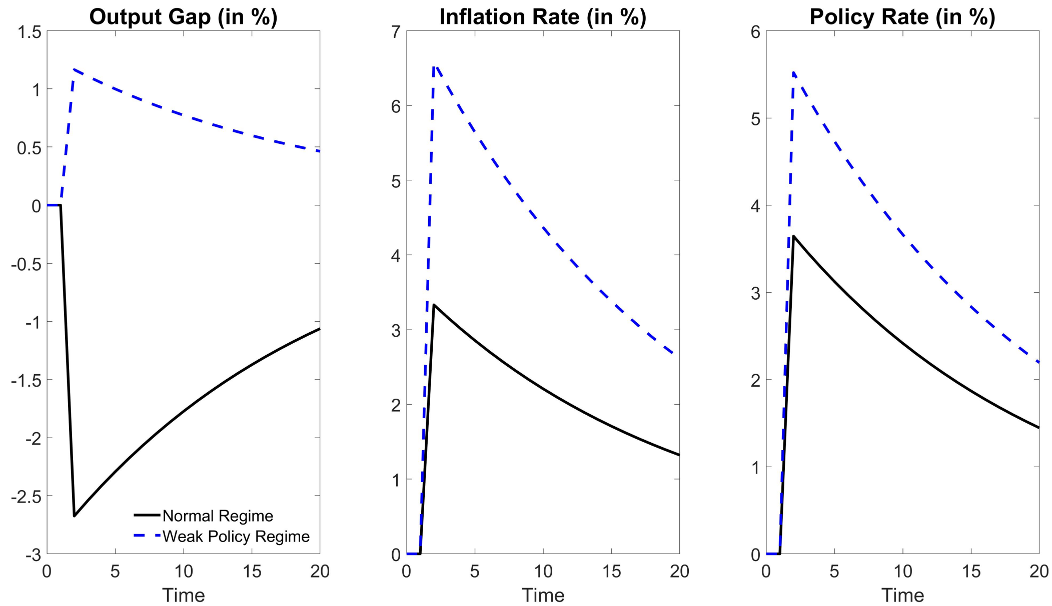
The sample period is from 2002:M1 to 2021:M8. The top panel plots the overnight borrowing rate before 2011 and the weighted average cost of CBRT funding thereafter. The middle panel gives the estimate of $\phi_{\pi,t}$ in equation (10) as the (black) dotted line, with the 95% confidence interval as the (red) dashed lines. The bottom panel displays the estimate of ϑ_t in equation (10). The (blue) vertical dotted lines denote tenures of the central bank governors.

Figure 10: The Taylor rule with time-varying parameters



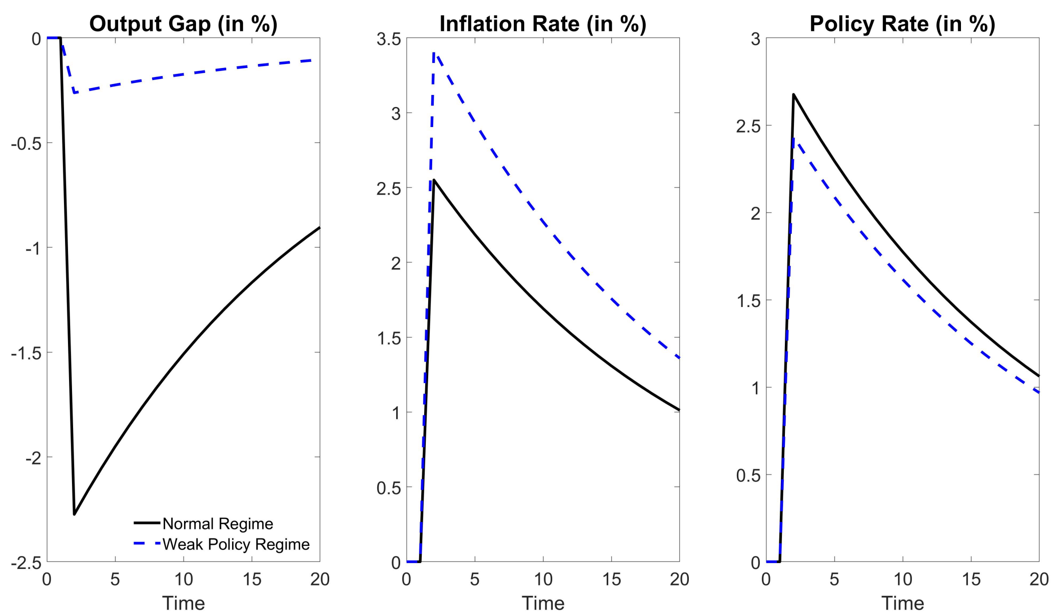
The sample period is from 2011:M1 to 2021:M8. The top panel plots the weighted average cost of CBRT funding. Other conventions are identical to those in Figure 9.

Figure 11: Impulse response functions based on a regime-switching New Keynesian model



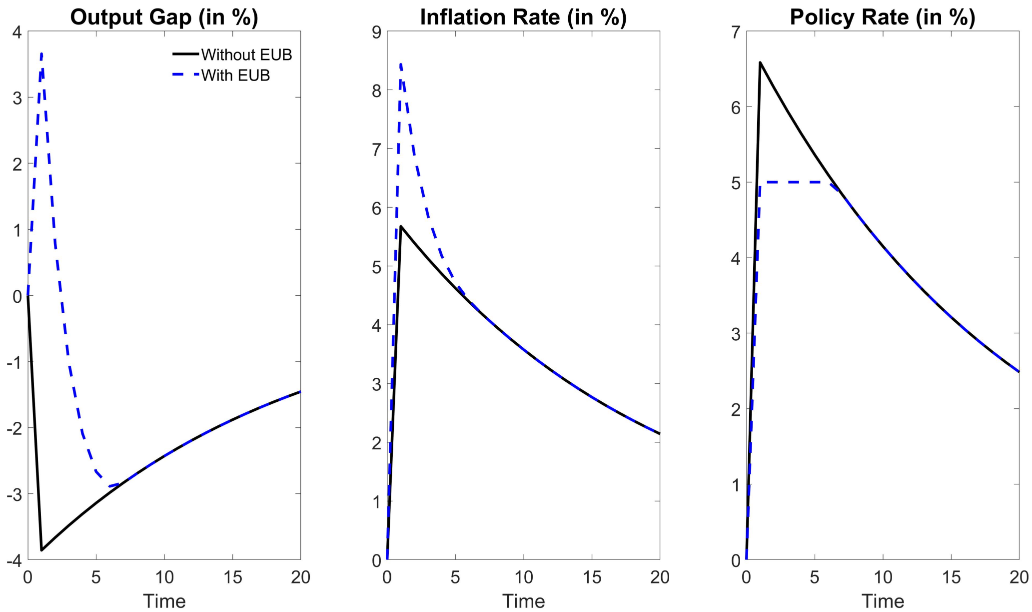
The (black) solid line is the reaction under the normal regime and the (blue) dashed line is the reaction under the weak policy regime, both to one standard deviation positive inflation shock. See the text for the explanation.

Figure 12: A robustness check for the regime-switching New Keynesian model



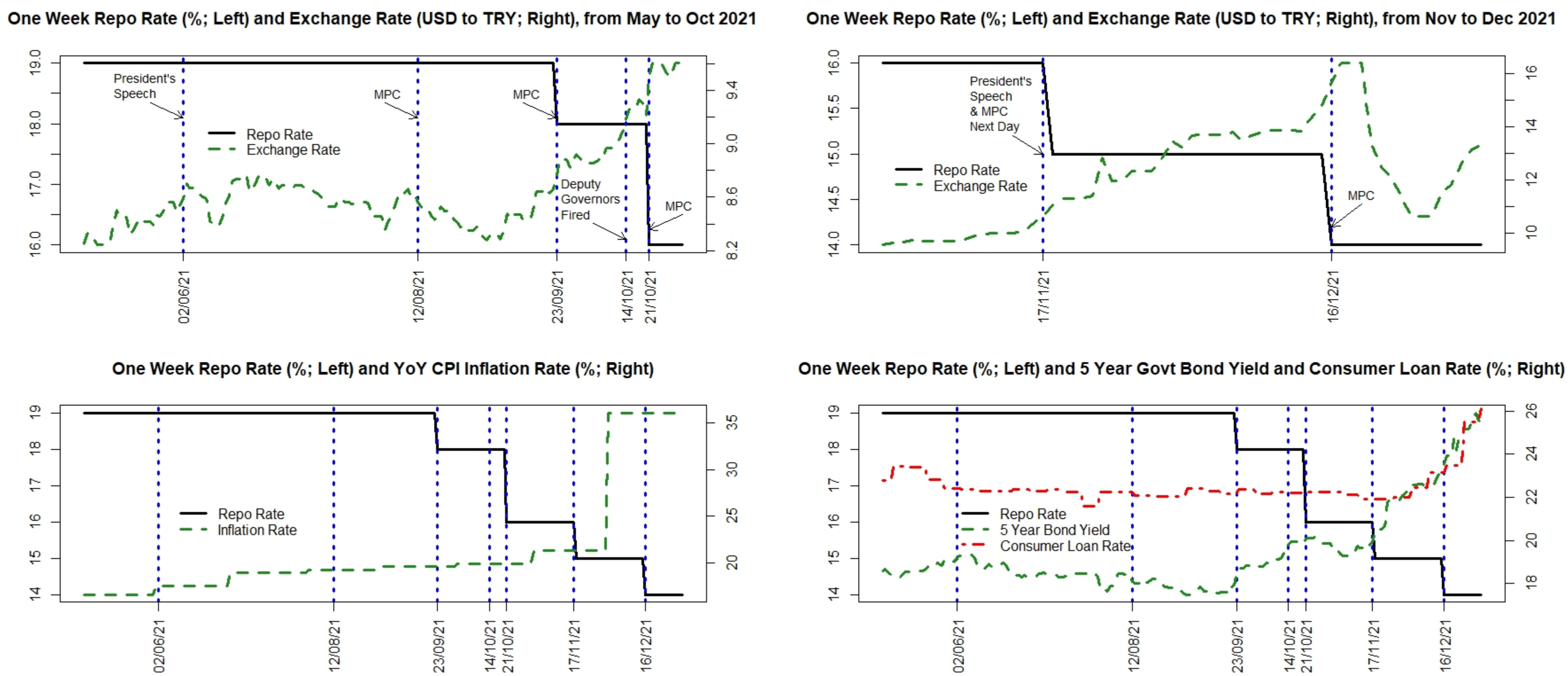
The figure is based on $\pi_{11} = 0.7$ instead. See the text for the explanation.

Figure 13: Impulse response functions based on a New Keynesian model with the effective upper bound on the policy rate



The (black) solid line is the reaction without the effective upper bound on the policy rate and the (blue) dashed line is the reaction with it, both subject to two standard deviation positive shocks to the output gap and the inflation rate. See the text for the explanation.

Figure 14: Event study



The two upper panels plot one week repo rates ((black) solid line) and nominal exchange rates ((green) dashed line), from May to October 2021 (left panel) and November to December 2021 (right panel), respectively. The series are available at daily frequency. The lower left panel gives one week repo rates ((black) solid line) and year-over-year CPI inflation rates ((green) dashed line). The inflation rates are the realized values for the corresponding months, available at monthly frequency. The lower right panel charts one week repo rate ((black) solid line), 5 year Treasury bond yield ((green) dashed line), and consumer loan rate ((red) dot dashed line). Whereas the bond yield is available at daily frequency, the loan rate (which are based on personal, vehicle, and housing loans) is available at weekly frequency from the CBRT. The vertical (blue) dotted lines denote key events as described by the texts above the arrows.

Appendix A - Univariate unobserved component model

The baseline univariate unobserved component (UC) model is a state space model, which decomposes an observed time series into trend, seasonal, and irregular components as introduced in Harvey (1989). The model specification preferred by the Akaike and Bayesian information criteria is

$$\triangle s_t = \mu_t + \epsilon_t$$

$$\mu_t = \mu_{t-1} + \beta_{t-1} + \eta_t$$

$$\beta_t = \beta_{t-1} + \zeta_t$$

where $\epsilon_t \overset{iid}{\sim} N(0, \sigma_\epsilon^2)$, $\eta_t \overset{iid}{\sim} N(0, \sigma_\eta^2)$, and $\zeta_t \overset{iid}{\sim} N(0, \sigma_\zeta^2)$. In this specification, μ_t is designed to capture a slow-moving or low-frequency component, so it is referred to as the trend and ϵ_t a fast-moving or high-frequency component, so it is referred to as the irregular. β_t is the slope of μ_t that is subject to its own dynamics. When $\sigma_\eta = \sigma_\zeta = 0$, $\mu_t = \mu_0 + \beta_0 t$ which is isomorphic to $\mu + \beta t$, and in this case the UC model reduces to the regression equation (6).

The model is estimated using the ML via Kalman filter for the sample period of 2003:Q1 to 2021:Q3. Table A1 provides the maximized log-likelihood and the estimates of the standard deviation parameters based on the Turkish lira exchange rate. The relatively large value of σ_ϵ reflects the high volatility of the lira exchange rate, and the small values of σ_η and σ_ζ suggest that the trend component is indeed slow-moving.

Figure A1 provides the Kalman smoothed estimate of the trend component μ_t. It shows that the trend component became statistically significantly different from zero starting from 2011:Q2, with no reversion back to zero thereafter. The rate of the depreciation has accelerated over the years, confirming the results of the regression analysis in Section 3.[24]

In cross-country comparison, using the UC model above, it turns out that only Brazil (BRL) and Peru (PEN) among Latin American countries continue to exhibit statistically significant upward sloping trend (a discussion on why this is so is provided in Section 5.1). Only these two countries are presented in the interest of space, along with Korea (KRW) as an example of a country with a flatter trend path, in Figure A2. The figure for Turkey (TRY) is also reproduced there for the ease of comparison. The figure again confirms the findings in Section 3 that Turkey stands out in terms of the estimated size of the trend component, the timing of the beginning of statistically significant deviations from zero also being earlier than the rest.

Even though the univariate analysis is informative regarding the exchange rate dynamics, it ignores feedback effects through macroeconomic fundamentals such as inflation. This is

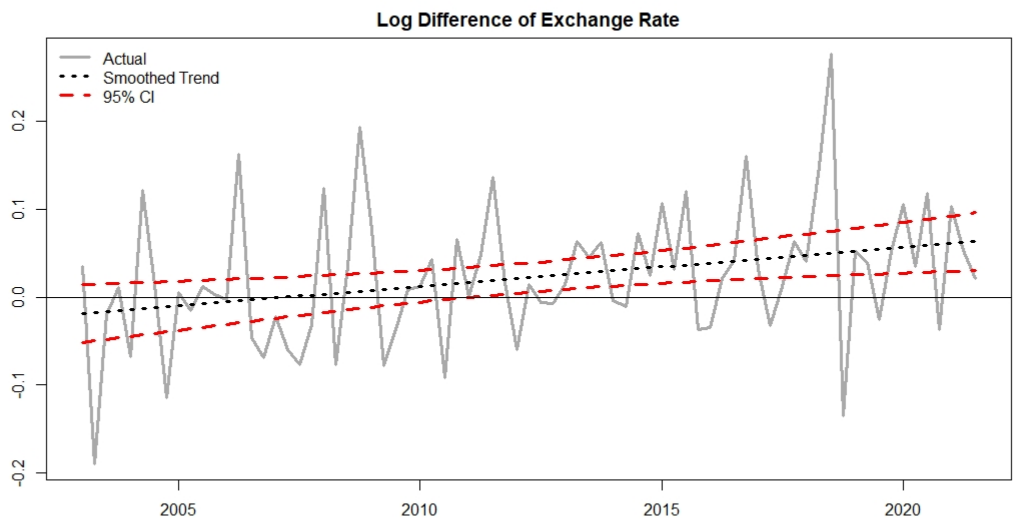
[24] The results continue to hold in various sub-samples that start later than 2003:Q1.

tackled in Section 4.

Table A1: The maximized log-likelihood and the estimates of the parameters

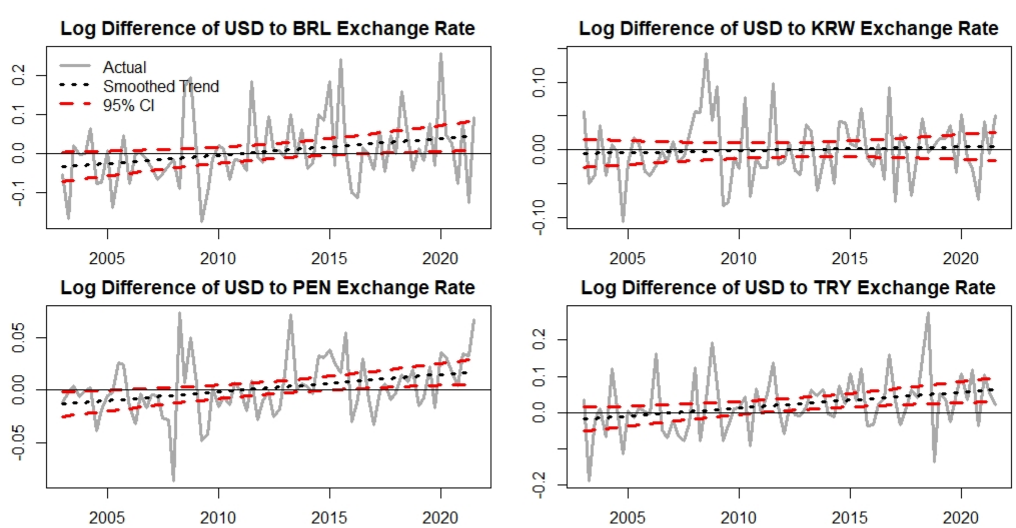
Log-likelihood	σ_ϵ	σ_η	σ_ζ
130.425	0.074	4.004E-6	1.364E-16

Figure A1: The Kalman smoothed estimate of μ_t



The (gray) solid line shows the quarter-over-quarter percentage change in the Turkish lira exchange rate from 2003:Q1 to 2021:Q3. The (black) dotted line gives the Kalman smoothed estimate of the trend component μ_t. The (red) dashed lines plot the 95% confidence interval.

Figure A2: The estimates of μ_t across countries



See Figure A1 for the convention.

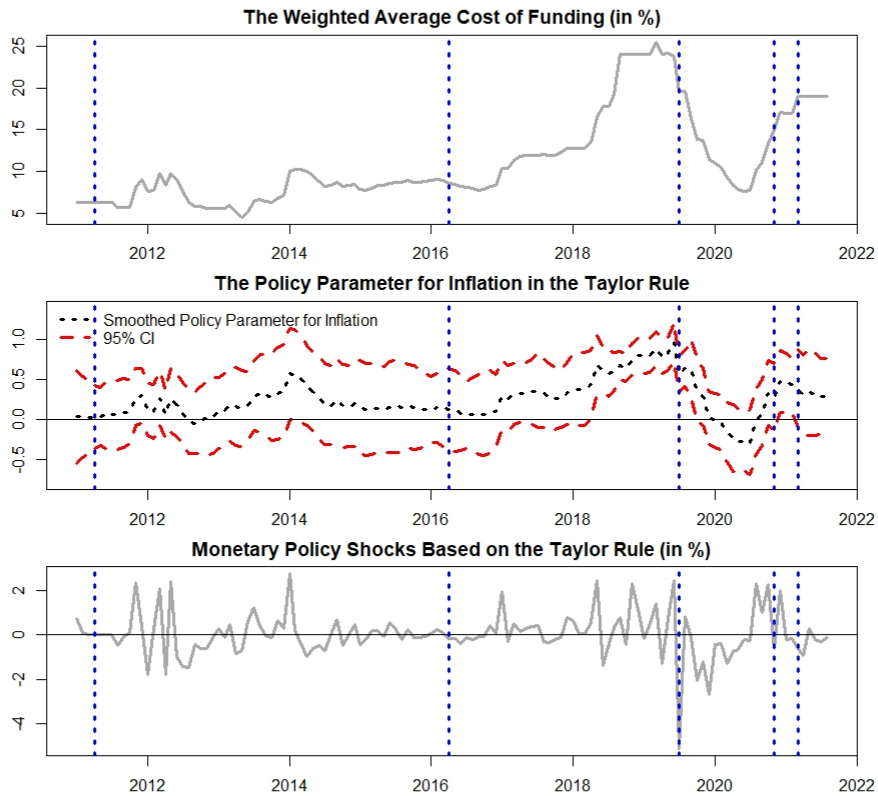
Appendix B - The Taylor rule based on the best-fitting inflation targets

The results in Section 5.3 are based on the assumption that the public sees the official inflation target of the central bank as credible. It is possible to inspect whether the fit of the model is sensitive to different values of the inflation target levels during the tenures of different governors. Intuitively one might think different inflation target levels as a way of capturing different perceived long run inflation levels during different periods. The grid search in the space of the inflation target for the period starting March 2021, with increments of 0.25% gives the best-fitting inflation target of 11% for this period, with the maximized log-likelihood increasing from 498.788 above to 501.153. Performing grid search for the period starting November 2020 gives the best-fitting inflation target of 7.25% for the period of November 2020 to February 2021 and 11% for the period starting March 2021, with the maximized log-likelihood of 502.146.

Figure B1 illustrates the results of the latter exercise, which confirms that the results before March 2021 are little changed. It also indicates that the downward drift of the inflation parameter started immediately after March 2021 rather than with some delays as shown in Figure 10. Adding the monthly percentage change in the Turkish lira exchange rate to the Taylor rule model for Figure B1 and also allowing its parameter to be time-varying do not change the results (not shown). Given that its maximized log-likelihood is 492.397, which is lower than the values for the more parsimonious models above, it is possible to conclude that there is no convincing evidence for the exchange rate targeting in this sample period.[25]

[25] The estimation based on different model specifications, for instance one where r_t is constrained to be constant, or different data, for instance where the realized inflation rate is replaced by the expectation of market participants or the output growth is exchanged with a measure of output gap, gives the results similar to those above with the the latter being on the conservative side in terms of their deviations from the Taylor principle. Also note that during at least some of this period, the CBRT was actively intervening in the foreign exchange market by selling foreign currency reserves, which enabled keeping the interest rate low, at the cost of running down reserves. The total loss of reserves were upwards of $120bn, with ex-swap net reserves being negative at the end of the period.

Figure B1: The Taylor rule with the inflation targets obtained from grid search



The figure is based on the inflation target of 7.25% rather than 5% for the period of November 2020 to February 2021 and 11% rather than 5% for the period starting March 2021. The sample period is from 2011:M1 to 2021:M8. The top panel plots the weighted average cost of CBRT funding. The middle panel gives the estimate of $\phi_{\pi,t}$ in equation (10) as the (black) dotted line, with the 95% confidence interval as the (red) dashed lines. The bottom panel displays the estimate of ϑ_t in equation (10). The (blue) vertical dotted lines denote tenures of the central bank governors.