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Structural breaks and monetary dynamics: A time series analysis

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ABSTRACT

This article investigates the stability of money demand and implications for the conduct of monetary policy in Egypt. The econometric procedures include testing for structural breaks at unknown dates and conditioning on the most recent break for estimation and forecasting. Test results provide evidence for regime shifts and lend support to the use of short-term interest rate as the main policy instrument. Sources of structural change are detected by a state-space model. Also, using a structural vector autoregressive (VAR) model for short-run dynamics, it is found that narrow money is a more appropriate monetary aggregate for policy analysis.

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1. Introduction

The demand for money in open economies is normally affected by developments in the foreign exchange market. Studies that emphasize the important role of currency substitution and capital mobility in modeling money demand include Arango and Nadiri (1981), Miles (1981), Cuddington (1983), Ortiz (1983), McNown and Wallace (1992), Arize and Shwiff (1993), Ericsson and Sharma (1998), Wu and Hu (2007), Narayan (2007), and Narayan et al. (2009). The present work follows a similar approach with application to Egyptian data at quarterly frequency over the period 1975:Q1–2012:Q2 of gradual reforms towards a market-oriented economy. The data is split into an in-sample period (1975:Q1–2010:Q2) for estimation and inference and an out-of-sample period (2010:Q3–2012:Q2) for forecast evaluation and policy analysis. The held-out data for ex post forecasting spans two years as is typical in monetary policy analysis, representing about 5% of the full sample.

Economic reasoning and institutional knowledge about policy making in a given economy are key elements for structural inference and analysis. In this regard, the conduct of monetary policy in Egypt is characterized by the use of price stability as the primary objective, short-term interest rate as the main operating instrument, and monetary aggregates as intermediate targets. This policy design recognizes the importance of monitoring monetary aggregates in pursuing a low inflation target through interest rate rules as shown in Reynard (2007) and Beck and Wieland (2008). In other settings, interest rate rules are used for inflation targeting without necessarily monitoring the monetary aggregates because of velocity shifts and financial innovations as studied in Lubik and Shorfheide (2007) and Christiano et al. (2011). Alternatively, money supply may be used as the monetary policy instrument for controlling inflation provided the demand for money is stable as discussed in Narayan (2008, 2010), Narayan and Narayan (2008), Rao and Kumar (2009), and Kumar et al. (2013).

This article investigates the stability of money demand and the suitability of using interest rate instead of money supply as the operating instrument for monetary policy in Egypt. It proposes an econometric framework for modeling monetary dynamics and forecasting inflation where the choice of an intermediate target plays a role in the efficacy of monetary policy. To that end, the analysis uses univariate and multivariate time-series techniques to test for structural break in the long-run demand for money and to study monetary dynamics in response to interest rate decisions at typical short-to-medium horizons. Ex post forecast evaluation is also carried out to determine whether narrow or broad money is a more effective intermediate target.

The article contributes to the literature in two ways. First, it identifies the sources of parameter instability using a state-space model for the long-run relationship when there is no evidence of cointegration with structural breaks. Second, it studies dynamic interactions in the short run using out-of-sample forecasting and a structural vector autoregressive (VAR) analysis conditional on the most recent break. The empirical results have implications for the conduct of monetary policy in terms of determining the appropriate instrument and intermediate target to achieve the objective of price stability.

The univariate analysis focuses on examining the order of integration of the time series using unit root tests with structural breaks at unknown dates and allowing for both level and trend shifts. These general test specifications are applied sequentially to the cases of one and two structural breaks using two alternative approaches that endogenously determine break points for robustness checks. Specifically, one approach uses Dickey and Fuller (1979) type unit-root test where the presence of breaks is only allowed under the alternative hypothesis of stationarity and the other approach uses a Lagrange multiplier (LM) type test developed by Schmidt and Phillips (1992), Ahn (1993), and

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Amsler and Lee (1995) where breaks are allowed under both the null and alternative hypotheses. The main interest here is to allow for discrete breaks as opposed to gradual changes in the regression function that can be captured by innovational outliers in trending series as proposed in Narayan and Popp (2010, 2013). Also, multiple breaks greater than two are not considered here as they can induce loss of power by reducing the distinction between a random walk and a trend break in the series.

The ADF-type test poses difficulties in the interpretation of results as noted in Nunes et al. (1997), Lee and Strazicich (2001, 2003), Perron (2006), Westerlund and Edgerton (2007), and Lee et al. (2012). For example, in the augmented Dickey–Fuller (ADF) type test, rejection of the null hypothesis of unit root may incorrectly indicate that the time series is stationary without breaks. In contrast, the LM-type test provides a sharper interpretation of results since not rejecting the null implies that the series is non-stationary. If the outcome of the two types of tests is the same in terms of rejecting or not rejecting the null, then the results are robust to test specification. In case of conflicting results, however, the LM-type test eases interpretation and identification and so can be selected for inference.

In this regard, it is noteworthy that unlike the ADF-type test, the asymptotic distributions of the LM test depend on nuisance parameters associated with structural change such as break magnitude and location for the individual series. This suggests calculating critical values for the test on a case-by-case basis, which may be inconvenient because of the computational cost. Yet, Lee et al. (2012) have shown that data transformation procedures can remove the dependence on nuisance parameters and permit providing critical values that can be used throughout for the specified number of structural breaks.

Within the ADF-type tests, Lumsdaine and Papell (1997) have proposed testing for unit root with two structural breaks for more reliable inference than the Zivot and Andrews (1992) test with a single break. Although the Lumsdaine and Papell (LP) test has higher power with strengthened case against the random walk model and good size properties, it may be still useful to consider the Zivot and Andrews (ZA) test for determining the number of breaks in a time series sequentially. In particular, LP test does not allow for a break under the alternative hypothesis of stationarity. Thus, rejecting the unit root null with two breaks does not necessarily imply the absence of breaks, especially when the ZA test provides evidence for a stationary series.

The univariate analysis is carried out using the ZA test and LP test under the ADF-type approach and the LSM test of Lee et al. (2012) under the LM-type approach. These tests provide evidence for non-stationary series with structural breaks. The Dickey and Fuller (1979) ADF and Elliott et al. (1996) ADF-GLS unit-root tests are then applied to first differences to determine the order of integration for each series. The results imply that all variables in the money demand function are integrated of order one, I(1), and so suggest testing for cointegration with a possible structural break in the long-run relationship.

The present work considers two types of tests for cointegration with structural change allowing for both intercept and slope shifts at an unknown date for robustness checks. These are the Gregory and Hansen (1996) residual-based test and the Westerlund and Edgerton (2007) LM-type test that endogenously determine the break point. Other tests of parameter non-constancy in long-run relationships include Hansen (1992) and Bierens and Martins (2010), however, they do not give break date estimates. The Gregory and Hansen (GH) test allows for breaks only under the alternative hypothesis of cointegration whereas the Westerlund and Edgerton (WE) test allows for breaks under both the null and alternative hypotheses. Thus, as in the univariate case, the WE test gives a sharper interpretation of results and has good power and small size distortion relative to the other test as noted in Westerlund and Edgerton (2007).

The critical values of these two types of cointegration tests are provided on a case-by-case basis because of the dependence of the asymptotic null distribution on the regressors in the case of GH test and on the nuisance parameters associated with structural change as well as the regressors in the case of WE test. Specifically, the GH test depends on the number of regressors whereas the LM-type test depends in addition on the magnitude of breaks in the slope parameters and break location. In this study, the exact or sample-specific critical values are provided for the GH test for the case of five regressors with stochastic trends and for the WE test with the same information on regressors in addition to the estimates of slope breaks and break date in a long-run relationship using Monte Carlo simulations.

Results of the two types of cointegration tests indicate regime shifts with parameter non-constancy in the demand for money equation and so monetary policy analysis cannot be based on model specifications with adjustment to a stable long-run equilibrium. Otherwise, one can expect negative repercussions associated with wrong inferences about the conduct of policy (see e.g. Nagayasu, 2003). The results lend support to the use of short-term interest rate as the main policy instrument.

The evidence on structural instability contrasts with empirical findings in earlier works on modeling money demand in an open economy. For example, Chowdhury (1995), Darrat et al. (1996), Bjornland (2005), and Hunter and Ali (2014) point out that failure to account for international factors increases the possibility of parameter non-constancy in the long-run relationship of money demand. However, they do not test for regime shifts and hence cannot adequately detect whether the different shocks are absorbed into a given model in the long run.

Also, the present work allows identifying potential causes of instability in the demand for money by proposing a state-space model that depicts evolution of the regression coefficients in the long-run relationship. The estimation results suggest that structural change is related to phased-in reforms in the foreign exchange market. This finding is largely consistent with the break date estimates whether for the exchange rate series or regime shift in the money demand equation.

In studying short-run dynamics, Granger causality tests are carried out to account for information flow among the variables and a possible feedback system. In light of the test results and the absence of a stable long-run equilibrium, a structural VAR model provides an efficient framework for monetary policy analysis using impulse response functions with bootstrap confidence intervals and variance decompositions of the innovations. Causality link among the model variables is specified according to existing policy instrument and targets for structural inference.

For estimation and forecasting, the alternative approaches in the presence of breaks are to use expanding windows, rolling windows, or post-break observations. In general, forecasting conditional on the most recent break performs better over unconditional approaches that use expanding or rolling windows as discussed in Pesaran and Timmermann (2002, 2004).[1] This approach is followed also here by testing for structural breaks in VAR models at unknown points in time using the methods of Andrews (1993), Hansen (1997), and Bai et al. (1998). As noted in Perron (2006), allowing for structural change in a multivariate system accounts, at least partially, for possible changes in the marginal distribution of the variables and avoids spurious inferences (see Hansen, 2000).

The stability test is carried out sequentially to endogenously determine the break points and the post-break observations for out-of-sample forecasting. The appropriate monetary aggregate for the conduct of monetary policy can be determined then by considering performance evaluation for the narrow and broad money models at various horizons. This procedure also provides a robustness check using subsample data analysis in the spirit of the work by Narayan et al. (2013). Although data-frequency analysis provides another check for the robustness of results in prediction models, it requires the availability of data at higher frequencies as well (see Narayan and Sharma, 2015a). In this context, the evaluation of out-of-sample inflation forecasts in

[1] Forecasting techniques vary over various topics in economics and finance. See, for example, Narayan and Sharma (2014, 2015b), Burns and Moosa (2015) and Kumar (2015).

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