README for
"Estimating Macroeconomic Models of Financial Crises: An Endogenous Regime-Switching Approach"*

Quantitative Economics

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1 Data Availability

The data all come from publicly available sources.

National accounts are from the National Statistic Office. The data series used in the analysis merge two sets of official statistics by updating the level of the national accounts based on 1993 constant prices with the quarterly rate of growth of the accounts based on 2008 constant prices. The merging is necessary as the deflators to splice the accounts in levels were not available at the time of the last download of the data (May 2017). The two sets of national accounts overlap from 1993:Q1 to 2006:Q4. Over this period, the difference in annual rate of growth is less than 0.01 percent in absolute value for GDP, less than 0.05 percent for consumption, less than 2 percent for investment, and less than 1 and 3 percent for imports and exports, respectively. The correlations between the series are more than 0.9 for all series except investment, which is 0.84, pointing to possibly larger measurement errors

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in this variable. The differences are smaller, the closer to the end of the sample period. For this reason, we choose to update the 1993 accounts rather than backdate the 2008 ones.

The specific sources of the data are as follows:

- 1980:Q1-2006:Q4 (Labeled 1993 accounts)—Supply and demand of goods and services. Original Series (not seasonally adjusted). Constant prices, annual 1993 = 100. We obtained these from the Central Bank of Mexico (Gabriel, 2008).

- 2006:Q1-2016:Q4 (Labeled 2008 accounts)—Supply and demand of goods and services. Original series (not seasonally adjusted). Constant prices, annual 2008 = 100 (Oferta y demanda de bienes y servicios. Series originales. A precios constantes 2008). Originally obtained from `http://www.inegi.org.mx/sistemas/tabuladosbasicos/tabdirecto.aspx`. At the time of publication, available from: `https://www.inegi.org.mx/programas/ofyd/2008/`.

The data are not seasonally adjusted and show a strong seasonal pattern. To seasonally adjust all series (assumed to be I(1) processes), we adjust the log-difference used the X-12 procedure with the additive option in Eviews. We then used the log of the first observation of the raw series (not seasonally adjusted) and cumulated the seasonally adjusted log-difference. The net exports to GDP series is calculated as real exports minus real imports divided by real GDP.

The current account as a percentage of GDP is from the balance of payment statistics originally obtained from the OECD Economic Outlook Database (Series MEX.CBGDPR.Q, OECD-EO-MEX-CBGDPR-Q).

As a proxy for the relative price of intermediate goods, entered as observable in estimation, we use a measure of Mexico's terms of trade obtained from Banco de México (PPI Producer and International Trade Price Indexes, series SP12753).

Mexico's country interest rate is calculated following Uribe and Yue (2006) as

$$r_t = r_t^* + spread_t \tag{1}$$

where r^* is the US real interest rate, and *spread* is a proxy for Mexico's country risk or sovereign spread. We compute r^* as 3-month Treasury Constant Maturity Rate adjusted for ex post CPI (annualized) quarterly inflation, using period average data. The source of these data is FRED. For the country spread, as customary, we use the Mexico's component of the JP Morgan EMBI.

Unfortunately, the EMBI spread has only been available since 1993. In order to estimate the country spread before 1993, we rely on empirical modeling of the relationship between the *domestic* real interest rates and country risk at the Banco de Mexico (Aportela Rodriguez et al., 2001) that estimates a close and stable relation between a measure of the domestic real interest rate and the EMBI spread over the period over which both these variables are available. The only quarterly interest series available we are aware of going back to 1980 is a three-month nominal short-term rate obtained from Banco de Mexico (Average monthly yield on 90-days Cetes, series SF3338).[1] So we estimate a relationship between this nominal interest rate, i_t, and the EMBI during the period over which the EMBI is observable, adjusting for inflation, π_t, which was an important source of nominal interest rate variation in the 1980s, and then invert it. Specifically, we posit the following simplified version of the model that (Aportela Rodriguez et al., 2001) estimate:

$$i_t = \alpha_0 + \alpha_1 \pi_t + \alpha_2 EMBI_t. \tag{2}$$

We then solve the fitted equation for the country risk component of the domestic real interest rate, which we denote as $E\hat{M}BI_t$. The estimated regression is (t-statistics in parentheses and $R^2 = 0.883$):

$$\hat{i}_t = \underset{(-0.42)}{-0.00346} + \underset{(4.46)}{0.397}\pi_t + \underset{(7.37)}{2.770}E\hat{M}BI_t. \tag{3}$$

All variables are in the file `\Data\BFOR Data.csv`.

2 Directory Info

- `\Data`: contains data for estimation (see Supplemental Online Appendix S.4)
- `\Figures and Tables`: all output of figures and tables for both paper and appendices
- `\FPI Comparison`: Paper Appendix C: Solution Accuracy and Comparison with Traditional Inequality Specification
- `\Main Model`: Main estimation and results code for the baseline model
- `\Mathematica Code Generation`: This code sets up the model and generates the perturbation matrices
- `\Model Alternatives`: estimation code and results for of alternative models

[1] There are three missing monthly observations in this series: August and September 1986 and November 1988. We fill these gaps using July 1986 for 1986Q3 and the average of October and December 1988 for 1988:Q4.

- `\Solver`: solution code for model variants without stochastic volatility
- `\Solver - SV`: solution code for model variants with stochastic volatility
- `\Utilities`: functions used in estimation and simulation

3 Information about the Code

We used Mathematica 13, and MATLAB R2022a including the MinGW-w64 Compiler for MEX files. We used a Linux cluster and Windows, with 2048 MB RAM.

Mathematica is used to set up the model and take the necessary derivatives for second-order perturbation, as described in Appendix B. This code automatically generates output that can be copied/pasted into the files in the `\Solver` and `\Solver - SV` directories. Note that this is not perfectly automated, as the user needs to make the code output compatible with MEX file language. This code is not required for replication purposes but is included to show the code generation process used.

The `\Solver` and `\Solver - SV` directories have the code that generates a second-order solution to the model.

Once the solvers are compiled, the code can be run to estimate the model:

- `main_estimation_mode.m` finds the posterior mode.
- From this posterior mode, MCMC can be run using `main_estimation_mcmc.m` and the model results can be generated using `main_postestimation_filtering.m`, `main_postestimation_simulations.m`, and `main_postestimation_counterfactuals.m` files.
- The alternative models can be estimated using the `alternatives_estimation_mode.m` file. Since this script is used to run multiple model types, the user needs to modify the code to select the appropriate model (line 18).
- For the Appendix accuracy and comparison results, we utilize a MATLAB code package we developed for solving endogenous regime-switching models that is available in the folder `\FPI Comparison\BFOR_Solution_Package`

4 Running the Code

The first step is to compile the solution code using `mex_all.m`. The second step is to compile the function `ff2_noloop_mex.m` in the directory `Utilities\Other\`.

The remaining code can be run in any order. Note that the MCMC and mode calculations default to 10 iterations. These should be updated as discussed in the main text.

- Figure 1: `main_data_plot.m`: 1 second
- Figure 2: `main_postestimation_simulations.m`: 1 hour
- Figure 3: `main_postestimation_filtering.m`: 1 minute
- Figure 4: `main_postestimation_filtering.m`: 1 minute
- Figure 5: `main_postestimation_filtering.m`: 1 minute
- Figure 6: `main_postestimation_counterfactuals.m`: 1 day
- Table 2: `main_estimation_mcmc.m`: 10 seconds per iteration
- Table 3: `alternatives_estimation_mode.m`: 1 week per model
- Table 4: `main_postestimation_simulations.m`: 1 hour
- Table 5: `main_postestimation_simulations.m`: 1 hour

- Figure C.1: `fpi_comparison.m`: 1 minute
- Figure C.2: `fpi_comparison.m`: 1 minute
- Table C.1: `fpi_compare_accuracy.m`: 1 minute
- Table C.2: `fpi_comparison.m`: 1 minute

- Figure G.1: `main_postestimation_filtering.m`: 1 minute
- Table G.1: `alternatives_estimation_mode.m`: 1 week per model

References

Aportela Rodriguez, F., J. A. A. Ituarte, and Y. C. Aguayo (2001). Comportamiento Histórico de Las Tasas de Interés Reales en México: 1951-2001. Documento de Investigación (Working Paper) No. 2001-0, Dirección General de Investigación Económica, Banco de Mexico.

Gabriel, G. (2008). Hechos estilizados del ciclo economico en mexico. Working Paper 2008-14, Banco de Mexico.

Uribe, M. and V. Z. Yue (2006). Country Spreads and Emerging Countries: Who Drives Whom? *Journal of International Economics 69*(1), 6–36.