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EXCHANGE RATE FORECASTING: THE FUNDAMENTAL FORECASTING MODEL

Dr. Ioannis N. Kallianiotis

Economics/Finance Department
The Arthur J. Kania School of Management
University of Scranton
Scranton, PA 18510-4602
Tel. (570) 941-7577
Fax (570) 941-4825
E-Mail: ioannis.kallianiotis@scranton.edu

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ABSTRACT

This paper is using the fundamental forecasting model, which is a monetarist theory of exchange rate determination, for the current forecasting. This theory is tested empirically by using data, spot and forward rates and a variety of macro-variables from seven different countries with respect the U.S., as our domestic country. A GARCH-M model is used to forecast the volatility of the spot exchange rate. The paper is also using a Vector Auto-regression (VAR) framework to forecast simultaneously spot (s_t) and forward (f_t) exchange rates by utilizing exogenous macro-variables, time trends, and policy instruments. Further, at the end an impulse response function and a Hodrick-Prescott filter are used to present visually the behavior of the spot exchange rate. The countries used in the empirical work are, U.S. with respect the Euro-zone, Mexico, Canada, U.K., Switzerland, Japan, and Australia. The results show that these methods are giving very good forecasting for these seven exchange rates by minimizing the standard error of the regression (SER) and the root mean squared error (RMSE). Of course, uncertainty exists always in the forecasting of any economic variables, due to unanticipated public policies (monetary, fiscal, and trade) and other "innovations" in our financial markets, plus the new philosophies (i.e., liberalism, lack of ethics, perversions, DEI, AI, wars, BRICS, etc.), official measurements, and value system in our markets, societies, and way of living.

KEYWORDS: Demand for Money and Exchange Rate, Foreign Exchange, Forecasting and Simulation, Information and Market Efficiency, International Financial Markets

I. INTRODUCTION

Exchange rate forecasting is a very difficult, but necessary task, so every effort is justifiable. Multinational corporations (MNCs), central banks, governments, banks, currency traders, foreign currency dealers, speculators, economists, and many others need forecasts of exchange rates for their policy decisions and for hedging decisions. Firms face the decision of whether to hedge future payables and receivables, which are in foreign currencies. Short-term financial and investment decisions require exchange rate forecasting to determine the ideal currency for borrowing money and to allocate the one that maximize the return of an investment. International capital budgeting decisions need forecasting of exchange rate to determine the expected cash flows and make an accurate decision for these foreign investments. Also, long-term financial decisions require forecasting of the currencies to decide from where to borrow money (which will reduce the cost if the currency is depreciated) and if it is better to issue a bond denominated in foreign currency.

Furthermore, earnings assessments want to forecast the foreign currencies, in which the earnings are coming from and decide if earnings are going to be remitted back to the parent company or to be invested abroad. Investors,[1] traders, and speculators need to forecast the exchange rate of their domestic currency with respect the currencies of the countries that they make business with them. Today, there is also an enormous unjustifiable, unethical, and suspicious competition (embargos, sanctions, restrictions, wars, exercise of power, controls, etc.),[2] currency war among the different nations (i.e., Ukrainian Hryvnia, Russian Rubles, Chinese yuan, etc.) and against the two dominant so far currencies (U.S. dollar[3] and euro), due to the peculiar foreign policies of the controlled and liberal EU and the U.S.A.[4]

Fundamental forecasting is based on fundamental relationships between economic variables and exchange rates. Then, all the theories of exchange rate determination, the Monetary Approach (Monetarist and Overshooting Model), the Portfolio Balance Approach, and others, can be used to forecast the value of the exchange rate next period. This type of analysis is called fundamental analysis, due to the economic fundamentals (macro-variables) that are used in the forecasting process. Thus, fundamental forecasting is the practice of using fundamental analysis to predict future exchange

[1] The U.S. net international investment position (IIP), the difference between U.S. residents' foreign financial assets and liabilities, was -$16.31 trillion at the end of the second quarter of 2022, according to statistics released by the U.S. Bureau of Economic Analysis (BEA). Assets totaled $30.98 trillion, and liabilities were $47.29 trillion. At the end of year 2021, the net investment position was -$18.12 trillion. Then, at the end of the first quarter of 2022, the net investment position was -$17.75 trillion, at the end of 2022:Q2 it was -$16.29 trillion, at the end of 2022:Q3 it was -$16.84 trillion, and at the end of 2022:Q4 it was -$16.12 trillion.. See, *International Investment Position*, https://www.bea.gov/data/intl-trade-investment/international-investment-position

[2] See, De Ruiter (2018).

[3] See, **United States Dollar,** https://tradingeconomics.com/united-states/currency

[4] The share of Russian exports to Brazil, India, China, and South Africa (BRICS) invoiced in U.S. dollars fell from 85% in Q2 2018 to 36% in Q4 2022. See, Nelson and Weiss (2022), file:///C:/Users/JK/AppData/Local/Microsoft/Windows/Temporary%20Internet%20Files/Content.IE5/92AFW49C/IF11707.pdf . See also, Carol Bertaut, Bastian von Beschwitz, Stephanie Curcuru (2021), In 2020, the U.S. dollar share as international reserve has fallen to 60%. https://www.federalreserve.gov/econres/notes/feds-notes/the-international-role-of-the-u-s-dollar-20211006.html . In 2022, the dollar as international reserve fell to 58.36%. See, https://en.wikipedia.org/wiki/Reserve_currency . See, also, Mearsheimer and Walt (2007).

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rates. This involves looking at all quantitative and qualitative aspects that might affect exchange rates, including macroeconomic data and political factors, as it is going on the last two years with the Ukrainian war, the Chinese dominance, and the new (liberal) public policies (monetary and fiscal).[5] Critics contend that fundamental forecasting is limited as some of the data it includes is difficult to quantify and it may miss some data that have an immediate effect of exchange rates. But in this case, we can use dummy variables[6] to measure the effects of political or other external events (crises, sanctions, wars, liberalism, WTO, COVID-19, DEI, AI, BRICS, etc.).

II. An Augmented Monetary Model of Fundamental Exchange Rate Forecasting

An augmented monetary model [eq. (1)] that is considered, here, for fundamental forecasting, is a descendant of the original models of Bilson (1978), Kallianiotis (1985, 1988, 2013, 2018b,c,d, 2019c, 2020a,b, 2021a,b,c, and 2022b), and Neely and Sarno (2002). It starts with the conventional money demand functions for both the domestic and foreign economies and through the PPP determines the current spot exchange rate by using lag values of the independent variables, as follows,

$$\begin{aligned} s_t &= \alpha + \psi(m_{t-1} - m^*_{t-1}) + \beta(y_{t-1} - y^*_{t-1}) + \gamma(i_{t-1} - i^*_{t-1}) + \delta(w_{t-1} - w^*_{t-1}) + \zeta(ca_{t-1} - ca^*_{t-1}) \\ &+ \theta(nd_{t-1} - nd^*_{t-1}) + \lambda(I_{t-1} - I^*_{t-1}) + \phi(p_{t-1} - p^*_{t-1}) + \mu(u_{t-1} - u^*_{t-1}) + \ldots + \varepsilon_t \end{aligned} \quad (1)$$

where, s_t = the ln of the current spot rate, m_{t-1} = the ln of the domestic money supply last period, y_{t-1} = the ln of domestic real income last period, i_{t-1} = the domestic short-term interest rate last period, w_{t-1} = the wage rate last period, ca_{t-1} = the ln of the current account last period, nd_{t-1} = the ln of the national debt last period, I_{t-1} = the ln of investment last period, and p_{t-1} = the ln of the domestic price level last period, u_{t-1} = the unemployment rate last period, ε_t = the error term, and an asterisk (*) denotes the foreign country.

Running the above regression, eq. (1), we receive estimates for the coefficients of all the independent variables ($\hat{\alpha}, \hat{\psi}, \hat{\beta}, \hat{\gamma}, \hat{\delta}, \hat{\zeta}, \hat{\theta}, \hat{\lambda}, \hat{\phi}, \hat{\mu}, \ldots$); then, we forecast the $E_t s_{t+1}$ by using the current values of the independent variables times the estimates of their coefficients.[7] Figure 1 gives the actual, [eq. (1)],

[5] See, Kallianiotis (2022a and 2023).
[6] See, Kallianiotis (2019c).
[7] An estimation of eq. (1) for S ($/€) is as follows:

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and fitted [eq. (2)], lines.

$$E_t\, s_{t+1} = \hat{\alpha} + \hat{\psi}(m_t - m_t^*) + \hat{\beta}(y_t - y_t^*) + \hat{\gamma}(i_t - i_t^*) + \hat{\delta}(w_t - w_t^*) + \hat{\zeta}(ca_t - ca_t^*) + \hat{\theta}(nd_t - nd_t^*) + \hat{\lambda}(I_t - I_t^*) + \hat{\phi}(p_t - p_t^*) + \hat{\mu}(u_t - u_t^*) + \ldots + \varepsilon_t \quad (2)$$

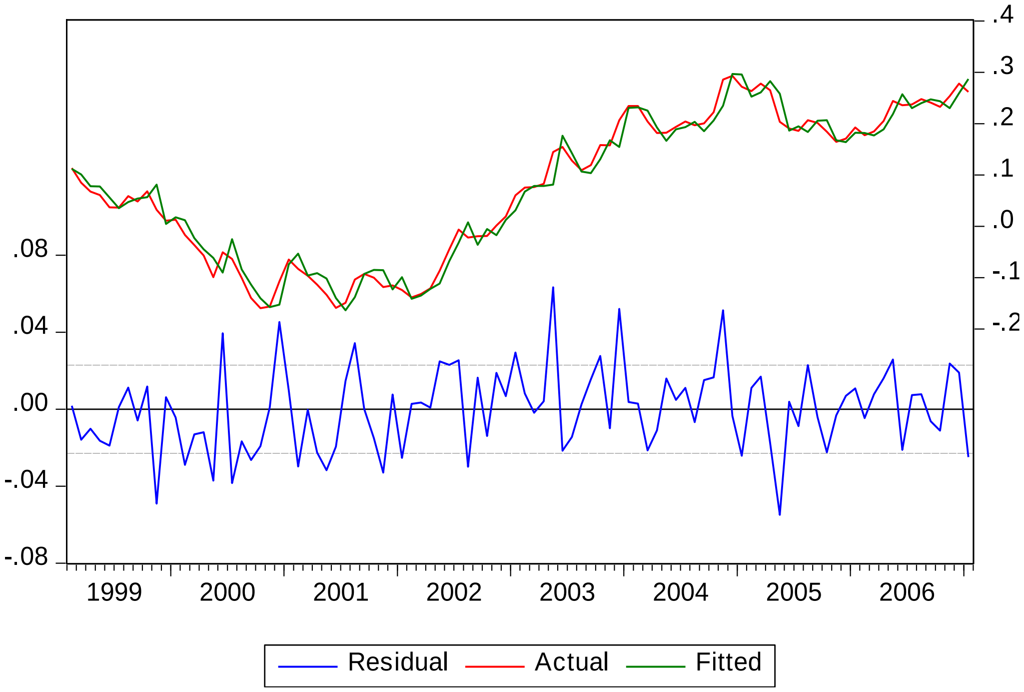

Figure 1: The Fundamental Forecasting of the Constrained Equation, eq. (1)

Note: Actual = LEUS = ln of European spot exchange rate ($/€) and Fitted = LEUSF= forecasted ln of European spot exchange rate by using eq. (1).
Source: *Economagic.com*

The above equation is the constrained one; an unconstrained model (allowing different

$$s_t = -3.084^{**} - 2.273^{***}(m_{t-1} - m_{t-1}^*) + 4.003^{***}(y_{t-1} - y_{t-1}^*) + 0.106^{**}(i_{t-1} - i_{t-1}^*) - 0.756^{***}(ca_{t-1} - ca_{t-1}^*)$$

(1.342) (0.398) (0.738) (0.049) (0.230)

$$+ 0.071(I_{t-1} - I_{t-1}^*) - 7.348^{***}(p_{t-1} - p_{t-1}^*)$$

(0.208) (1.127)

$R^2 = 0.829$, $SER = 0.060$, $F = 71.833$, $D-W = 0.472$, $N = 96$

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elasticities in each country) can be used, too, and it is expected to give better results[8] (statistics and smaller RMSE).

$$s_t = \alpha_0 + \alpha_1 m_{t-1} + \alpha_2 m^*_{t-1} + \alpha_3 y_{t-1} + \alpha_4 y^*_{t-1} + \alpha_5 i_{t-1} + \alpha_6 i^*_{t-1} + \alpha_7 w_{t-1} + \alpha_8 w^*_{t-1} + \alpha_9 ca_{t-1} + \alpha_{10} ca^*_{t-1} + \alpha_{11} nd_{t-1} + \alpha_{12} nd^*_{t-1} + \alpha_{13} I_{t-1} + \alpha_{14} I^*_{t-1} + \alpha_{15} p_{t-1} + \alpha_{16} p^*_{t-1} + \alpha_{17} u_{t-1} + \alpha_{18} u^*_{t-1} ... + \varepsilon_t \quad (3)$$

By taking the values from the estimated coefficients ($\hat{\alpha}_0, \hat{\alpha}_1, \hat{\alpha}_2, ..., \hat{\alpha}_{18}$), eq. (3), and the current values of the independent variables, the $E_t s_{t+1}$ can be forecasted, the same way as in eq. (2); Figure 2 gives its visual presentation.

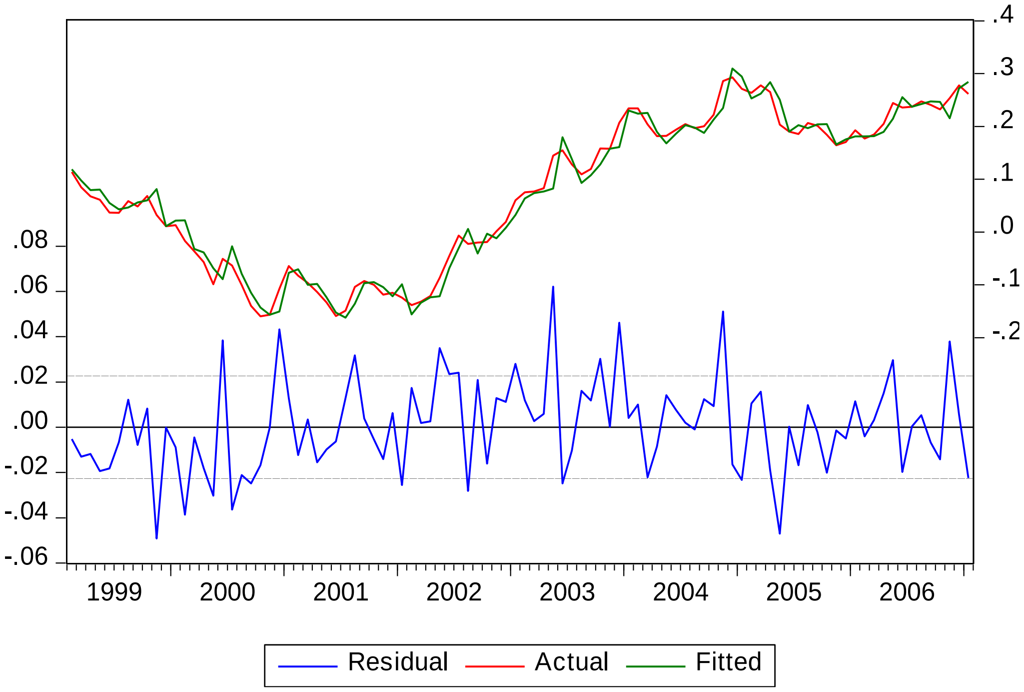

Figure 2: The Fundamental Forecasting of the Unconstrained Equation, eq. (3)

Note: Actual = LEUS = ln of European spot exchange rate ($/€) and Fitted = LEUSF= forecasted ln

[8] The unconstrained equation (3) for S ($/€) gives the results:

$$s_t = 12.233 - 0.148 m_{t-1} + 3.250^{***} m^*_{t-1} - 1.215 y_{t-1} - 0.587 y^*_{t-1} - 0.055 i_{t-1} + 0.048 i^*_{t-1} - 0.240 ca_{t-1}$$

(8.741) (0.916) (0.555) (1.707) (1.469) (0.054) (0.050) (0.313)

$$+ 0.208 ca^*_{t-1} + 0.973^{***} I_{t-1} - 2.062^{***} I^*_{t-1} - 2.703 p_{t-1} - 0.786 p^*_{t-1}$$

(0.284) (0.339) (0.663) (1.726) (2.893)

$R^2 = 0.889$, $SER = 0.050$, $F = 55.378$, $D-W = 0.618$, $N = 96$

of European spot exchange rate by using eq. (3).
Source: *Economagic.com*

III. Combining Regression Analysis with a Time-Series Model: Transfer Function Models

Suppose that we would like to forecast the variable $E_t s_{t+1}$ by using a regression model. Presumably such a model would include all those independent variables, which could provide an explanation for movements in s_t, but which are not themselves collinear. Let us suppose that the best regression model contains the following independent variables:

$$s_t = f\,[(m_{t-1} - m^*_{t-1}), (y_{t-1} - y^*_{t-1}), (i_{t-1} - i^*_{t-1}), (p_{t-1} - p^*_{t-1}), (tb_{t-1} - tb^*_{t-1}), (bd_{t-1} - bd^*_{t-1})] + \alpha_0 + \varepsilon_t \qquad (4)$$

This equation, as all the regressions, has an implicit additive error term (ε_t) that accounts for unexplained variance in s_t. It accounts for that part of the variance of s_t that is not explained by the other independent variables. Eq. (4) can be estimated and an R^2 will result, which will be less than 1. The equation can, then, be used to forecast $E_t s_{t+1}$. One source of forecast error would come from the additive noise term, whose values cannot be predicted.

Subtracting the estimated value of $E_t s_t = \hat{s}_t$ from the actual value s_t, we can calculate a residual series ν_t, which represents unexplained movements in s_t, a pure noise ($s_t - \hat{s}_t = \nu_t$). One effective application of time-series analysis is to construct an *Autoregressive Integrated Moving Average* (*ARIMA*) model for the residual series ν_t of the regression. We would then substitute the *ARIMA* model for the implicit error term in the original regression equation. When using the equation to forecast $\hat{s}_t$, we would also be able to make a forecast of the error term ε_t by using the *ARIMA* model. The *ARIMA* model provides some information as to what future values of ε_t is likely to be; it helps explain the unexplained variance in the regression equation. The combined regression-time series model is:

$$s_t = \alpha_0 + \mathrm{A}\, X_{t-1} + \Phi^{-1}(\mathrm{B})\,\theta(\mathrm{B})\, n_t \qquad (5)$$

where, X_t represents the independent variables and n_t is a normally distributed error term, which may have a different variance from ε_t.

This model is likely to produce better forecasts than the regression equation (4) alone or a time-series model alone, since it includes a structural (economic) explanation of that part of the variance of s_t that can be explained structurally and a time-series explanation of that part of the variance of s_t that

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cannot be explained structurally. Eq. (5) is referred to as a *transfer function* model or *multivariate autoregressive-moving average* model ($MARMA$).[9] This combined use of

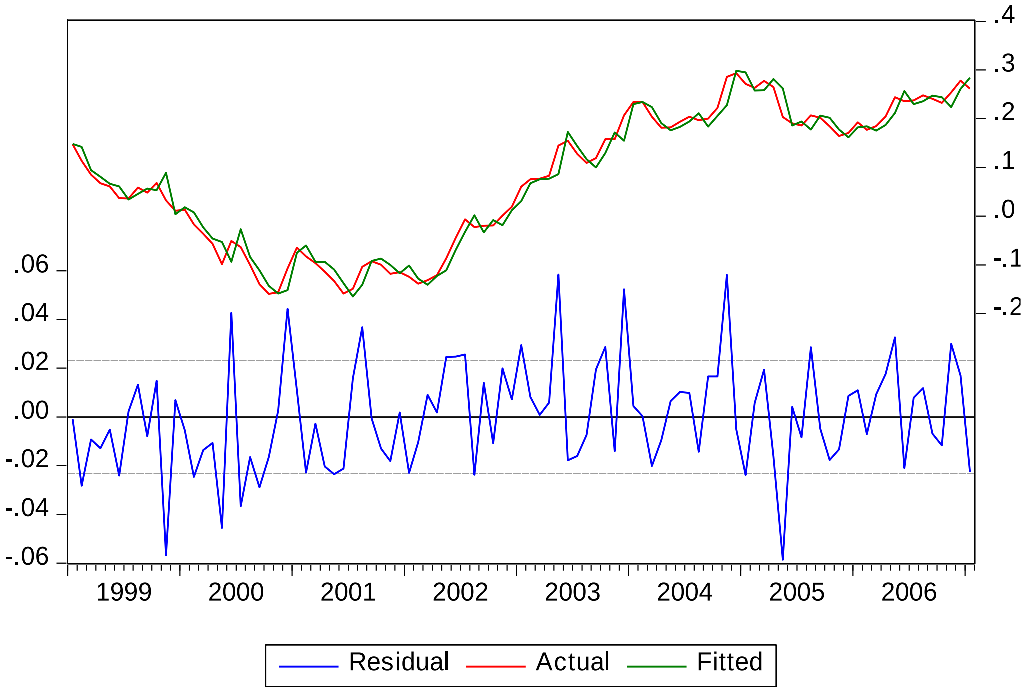

Figure 3: The Transfer Function of the s_t [eq. (5)]

Note: Actual = LEUS = ln of European spot exchange rate ($/€) and Fitted = LEUSF= forecasted ln of European spot exchange rate by using the eq. (5).

Source: *Economagic.com*

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regression analysis with a time-series model of the error term is a particularly powerful approach to forecasting $E_t s_{t+1}$, as it is shown in eq. (5) above, that in some cases can provide the best of both worlds,[10] Figure 3.

[9] A transfer function model simply relates a dependent variable to lagged values of itself, current and lagged values of one or more independent variables, and an error term, which is partially explained by a time-series model. The technique of transfer function modeling involves examination of partial and total autocorrelation functions for the independent variables X_t as well as the dependent variable s_t in an effort to specify the lag polynomials. The structural part of the model is arrived at through the mixture of the monetary approach theory and other econometric methods, while the time-series part of the model is arrived at through an analysis of the residuals of the structural model.

[10] The empirical results of eq. (5) are the following and Figure 3 gives the Actual and Fitted values of the $\ln S_t$:

(A) Constrained Model:

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IV. The GARCH-M Estimation

We also want to model, forecast, and test the significance of the volatility of the exchange rate (S_t). For this reason, we will use a Garch-in-Mean (GARCH-M) model, a Generalized Autoregressive Conditional Heteroskedasticity into the Mean equation.

The GARCH (q,p) variance can be presented as,

$$\sigma_t^2 = \omega + \sum_{j=1}^{q} \beta_j \sigma_{t-j}^2 + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-i}^2 \qquad (6)$$

where, ω = constant term, ε_{t-i}^2 = the lag of the squared residual (the ARCH term), news about volatility from the previous periods, and σ_{t-j}^2 = the previous forecasts variance (the GARCH term).

The GARCH-M model can be written as follows,

$$s_t = X_{t-1}^{'}\theta + \lambda\sigma_t^2 + \varepsilon_t \qquad (7)$$

where, X_{t-1}= the ln of exogenous or predetermined variables last period that are included in the mean equation (m, y, etc.).

The GARCH-M model is used in financial applications (i.e., S_t), where the forecasting of the dependent variable, $E_t s_{t+1}$, is related to the expected risk (fluctuations of S_t) and the current values of the $X_t^{'}$ variables, times the estimates of their coefficients. If the sum of the ARCH and GARCH

$$\underset{(1.281)}{s_t = 0.783} - \underset{(0.372)}{0.439}(m_{t-1} - m_{t-1}^*) - \underset{(0.510)}{0.149}(y_{t-1} - y_{t-1}^*) - \underset{(0.020)}{0.036^*}(i_{t-1} - i_{t-1}^*) - \underset{(0.092)}{0.026}(ca_{t-1} - ca_{t-1}^*)$$

$$- \underset{(0.944)}{0.507}(p_{t-1} - p_{t-1}^*) + \underset{(0.021)}{0.974^{***}} s_{t-1} + \underset{(0.118)}{0.362^{***}} \varepsilon_{t-1}$$

$R^2 = 0.975$, $SER = 0.023$, $F = 431.579$, $D-W = 1.954$, $RMSE = 0.022249$, $N = 97$

(B)Unconstrained Model:

$$s_t = \underset{(8.166)}{10.335} - \underset{(0.468)}{0.087}m_{t-1} + \underset{(0.505)}{0.704}m_{t-1}^* - \underset{(0.844)}{0.014}y_{t-1} - \underset{(0.866)}{0.976}y_{t-1}^* - \underset{(0.030)}{0.023}i_{t-1} + \underset{(0.024)}{0.050}i_{t-1}^* - \underset{(0.177)}{0.348^*}ca_{t-1}$$

$$+ \underset{(0.094)}{0.086}ca_{t-1}^* - \underset{(0.200)}{0.341^*}I_{t-1} + \underset{(0.472)}{0.632}I_{t-1}^* - \underset{(0.969)}{0.651}p_{t-1} - \underset{(1.318)}{1.317}p_{t-1}^* + \underset{(0.018)}{0.980^{***}}s_{t-1} + \underset{(0.121)}{0.411^{***}}\varepsilon_{t-1}$$

$R^2 = 0.978$, $SER = 0.023$, $F = 241.510$, $D-W = 1.936$, $RMSE = 0.020804$, $N = 96$

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coefficients (α+β ≅ 1) is very close to one, it indicates that volatility shocks are quite persistent.

V. Multi-equation Time-series Models

One of the most fertile areas of contemporary time-series research concerns multi-equation models. Many economic systems do exhibit feedback from other variables. It is not always known if the time path of a series designated to be the "independent" variable has been unaffected by the time path of the "dependent" variable. There is a type of analysis that treats all variables symmetrically without making reference to the issue of dependence versus independence, this is a Vector Autoregression (VAR) analysis.

When we are not confident that a variable is actually exogenous, a natural extension of transfer function analysis is to treat each variable symmetrically. In the two variable case, we can let the time path of $\{s_t\}$ be affected by current and past realizations of the $\{f_t\}$ sequence and let the time path of the $\{f_t\}$ sequence be affected by current and past realizations of the $\{s_t\}$ sequence.

Thus, a Vector Autoregression (VAR) is a system of equations that makes each endogenous variable a function of its own past and the past of the other endogenous variables in the system. A VAR has been proven a successful technique for forecasting systems of interrelated time series variables, i.e., money supply and price level. We use, here, a slight generalization of the simple VAR by allowing for the possibility that there may be exogenous variables that help determine the endogenous variables; the simplest exogenous variable can be a time trend (t) or any public policy instruments.

Then, our methodology involves estimating spot (s_t) and forward (f_t) exchange rates in a Vector Autoregression (VAR) framework with a time trend (t) component as,

$$\begin{aligned} s_t &= \alpha_{10} + \mathrm{A}_{11}(L)\, s_{t-1} + \mathrm{A}_{12}(L)\, f_{t-1} + \mathrm{A}_{13} t + \varepsilon_{st} \\ f_t &= \alpha_{20} + \mathrm{A}_{21}(L)\, s_{t-1} + \mathrm{A}_{22}(L)\, f_{t-1} + \mathrm{A}_{23} t + \varepsilon_{ft} \end{aligned} \tag{8}$$

where, α_{10} and α_{20} = constants, A_{ij} = the polynomials in the lag operator L , and t = time trend.

We can also use, as exogenous variables, for the above VAR system, macro-variables (x), the monetary policy instruments (central banks' target rates) for the two economies (i.e., i_{FF} and i^*_{OND}), and the time trend (t), in our case, here.

$$\begin{aligned} s_t &= \alpha_{10} + \mathrm{A}_{11}(L)\, s_{t-1} + \mathrm{A}_{12}(L)\, f_{t-1} + \mathrm{A}_{13}(L) x_{t-1} + \mathrm{A}_{14}(L) i_{FF_{t-1}} + \mathrm{A}_{15}(L) i^*_{OND_{t-1}} + \mathrm{A}_{16} t + \varepsilon_{st} \\ f_t &= \alpha_{20} + \mathrm{A}_{21}(L)\, s_{t-1} + \mathrm{A}_{22}(L)\, f_{t-1} + \mathrm{A}_{23}(L) x_{t-1} + \mathrm{A}_{24}(L) i_{FF_{t-1}} + \mathrm{A}_{25}(L) i^*_{OND_{t-1}} + \mathrm{A}_{26} t + \varepsilon_{ft} \end{aligned} \tag{9}$$

where, i_{FF}= U.S. federal funds rate and i^*_{OND}= ECB overnight deposit rate.

V.1. The Impulse Response Function and the Smoothing Method

The solutions of eqs. (8) and (9) are shown in Table A4 and can be used to examine the interaction between the $\{s_t\}$ and $\{f_t\}$ sequences. The coefficients can be used to generate the effects of ε_{st} on ε_{ft} shocks on the entire time paths of the $\{s_t\}$ and $\{f_t\}$ sequences. The four and the six sets of coefficients are called the *impulse response functions*. Plotting the impulse response functions is a practical way to visually represent the behavior of the $\{s_t\}$ and $\{f_t\}$ series in response to the various shocks. The appendix provides two figures (Figure A1 and A2), which trace out the effects of one-unit shocks to ε_{st} and ε_{ft}.

We can also use a smoothing method (a Hodrick-Prescott Filter)[11] to obtain a smooth estimate of the long-term trend component of the different exchange rate (S_t) series. The Hodrick-Prescott filter is a two-sided linear filter that computes the smoothed series τ of s by minimizing the variance of s around τ, subject to a penalty that constrains the second difference of τ. The series s_t is made up of a trend component (τ_t), a cyclical component (c_t), and an error component (ε_t) such that $s_t = \tau_t + c_t + \varepsilon_t$. Thus, the Hodrick-Prescott Filter chooses τ that minimizes the following function,

$$\sum_{t=1}^{T}(s_t - \tau_t)^2 + \lambda \sum_{t=2}^{T-1}[(\tau_{t+1} - \tau_t) - (\tau_t - \tau_{t-1})]^2 \tag{10}$$

Given an adequately chosen, positive value of λ, there is a trend component that will solve the above function. The larger the λ, the smoother become the σ of the series. As $\lambda \to \infty$, τ approaches a linear trend. For monthly data it is commonly used a λ=14,400.

VI. Empirical Results

We estimate eq. (1) and we use an *AR(p)* and *MA(q)*, transfer function, eq. (5), to correct for residual serial correlation, using data for the period 1973:01 to 2023:02. The equation results are shown in Table A1. To get a feeling for the fit of the model, we graph the residual for *LEUS*, Figure 1 and we see that the actual and fitted values are virtually indistinguishable. Then, we perform a forecast, a static forecast, which is a sequence of one-step ahead forecast (*LEUSF*) and we receive the *RMSE*= 0.02358 for *EUSF*. The smallest *RMSE* is with Canada (*LCSF*), *RMSE*= 0.01526 and the largest with Mexico (*LMSF*), RMSE = 0.03476. The evaluation of our forecast error for the seven exchange rates is given by the Root Mean Squared Error (*RMSE*) statistic by combining eq. (1) and eq. (5) in Table A1.

[11] See, Hodrick and Prescott (1997).

The estimation of the unconstrained model, eq. (3), in conjunction to eq. (5), appears in Table A2. The forecasting of the exchange rates by using the GARCH-M model, eq. (7), is presented in Table A3. The volatility of exchange rates has significant effects on the exchange rates forecasting, except for Japan ($/¥). The *ARCH* term is statistically significant except with Mexico ($/MP) and Japan ($/¥). The *GARCH* term is statistically significant with the six exchange rates, except with Japan ($/¥). Graph A1 presents the U.S. dollar index and its fluctuation, which depends on different economic and political events. Graph A2 shows the $/€ daily volatility. Figures A3 to A9 give the L-T trend component of the different spot exchange rates by using the smoothing method of Hodrick-Prescott filter. From these L-T trends, we see that the U.S. dollar is expected to appreciate with respect the €, MP, and A$; it is depreciated with respect the C$, £, SWF, and ¥. Table A4 gives the empirical results of eqs. (8) and (9) for the LEUS and LEUF and Figures A1 and A2 present the Impulse Response Functions.

VII. Forecasting Evaluation

Forecasts are made with errors because the economy is dynamic (guided),[12] controlled (dominated), and unpredictable (manipulated); the markets are deregulated and central banks private with anti-social policies.[13] Then, our information is restrained and many news are "fake" (predominate lies).[14]

[12] See, the Davos meeting (World Economic Forum) January 16-20, 2023, of the global "elites" (the "forerunners"). *Fox News*, 1/16-20/2023. Also, "Davos 2023: Key takeaways from the World Economic Forum", Davos 2023: Key takeaways from the World Economic Forum | Reuters

[13] See, Kallianiotis (2023 and 2022a).

[14] The public media are completely controlled; thus, most of the News are very subjective lies (pure propaganda), which have wrong effects on individuals' decisions, perceptions, and confidence. (*Sic*). See, "We are grateful to the Washington Post, the New York Times, Time Magazine and other great publications whose directors have attended our meetings and respected their promises of discretion for almost forty years. It would have been impossible for us to develop our plan for the world if we had been subjected to the lights of publicity during those years. But, the world is more sophisticated and prepared to march towards a world government. The supranational sovereignty of an intellectual elite and world bankers is surely preferable to the national auto-determination practiced in past centuries." David Rockefeller, Speaking at the June, 1991 Bilderberger meeting in Baden, Germany (a meeting also attended by then-Governor Bill Clinton and by Dan Quayle). https://rense.com//general17/quote.htm . But, President Woodrow Wilson had said that the U.S. lost control of its financial system by allowing its Central Bank to be independent of the government (private): "I am a most unhappy man. I have unwittingly ruined my country. A great industrial nation is controlled by its system of credit. Our system of credit is concentrated. The growth of the nation, therefore, and all our activities are in the hands of a few men. We have come to be one of the worst ruled, one of the most completely controlled and dominated Governments in the civilized world -- no longer a Government by free opinion, no longer a Government by conviction and the vote of the majority, but a Government by the opinion and duress of a small group of dominant men." [Woodrow Wilson President of the United States (1913-1921)]. Also, "There is no such thing, at this date of the world's history, in America, as an independent press. You know it and I know it. There is not one of you, who dares to write your honest opinions, and if you did, you know beforehand that it would never appear in print. I am paid weekly for keeping my honest opinion out of the paper I am connected with. Others of you are paid similar salaries for similar things, and any of you who would be so foolish as to write honest opinions would be out on the streets looking for another job. If I allowed my honest opinions to appear in one issue of my paper, before twenty-four hours my occupation would be gone. The business of the journalists is to destroy the truth, to lie outright, to pervert, to vilify, to fawn at the feet of mammon, and to sell his country and his race for his daily bread. You know it and I know it, and what folly is this toasting an independent press? We are the tools and vassals

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Thus, our models are only approximations of reality, and our actual knowledge is limited;[15] so, we cannot be wise. Suppose the true model is given by,

$$s_t = \chi_t \beta + \varepsilon_t \tag{11}$$

where, β is a vector of unknown parameters, and ε_t is an independent and identically distributed with mean zero random disturbance [$E(\varepsilon_t) = 0$].

The true model generating s_t is not known, but we obtain estimates $\hat{\beta}$ of the unknown parameters β. Then, setting the error term equal to its mean value (zero), the forecasts of s_t are obtained as follows:

$$\hat{s}_t = \chi_t \hat{\beta} \tag{12}$$

The forecast error (e_t) is the difference between the actual and the forecasted value,

$$e_t = s_t - \chi_t \hat{\beta} \tag{13}$$

Assuming that the model is correctly specified, there are two sources of forecast errors: (1) residual or innovation uncertainty and (2) coefficient uncertainty.

(1) Residual or Innovation Uncertainty

This first source of errors arises because the innovations ε_t in the equation are unknown for the forecast period and are replaced with their expectations. While the residuals are zero in expected value, the individual values are non-zero; the larger the variation in the individual errors, the greater the overall error in the forecasts. The standard measure of this variation is the "Standard Error of the Regression" (SER) in the equation output. Residual uncertainty is usually the largest source of forecast errors. Our criterion, here, will be minimization of the SER because the smaller the SER in our output, the better the forecast of this model. The SERs in our forecasting models are very small, from 0.015 to 0.035 for eqs. (1) and (3) and between 0.019 and 0.038 for eq. (7). The SEE for eq. (8) is between 0.021 and 0.027 and for eq. (9) from 0.020 to 0.025.

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of rich men [the Illuminati] behind the scenes. We are the jumping jacks, they pull the strings and we dance. Our talents, our possibilities and our lives are all the property of other men. We are intellectual prostitutes." by John Swinton, as "the former Chief of Staff at the *New York Times*", before the New York Press Club in 1953. What can we say so many years later, where individual liberties and freedom have been completely lost?

[15] The majority of the people do not know what the true ultimate objective in our lives is. For this reason, the L-T social trend is negative. A candidate for the Supreme Court Justice, during her Senate hearing said that she cannot define what a woman is. Now, she is a Justice. (*Sic*). The Secretary of Education was asked three times by a Senator: "What is a woman?" He said: "I do not know," This is our educational and justice system, today. Can we predict anything for the future of our world?

(2) Coefficient Uncertainty

The second source of forecast error is coefficient uncertainty. The estimated coefficients $\hat{\beta}$ of the equation deviate from the true coefficients β in a random fashion. The standard error of the estimated coefficient, given with the output from the regression, is a measure of the precision, with which the estimated coefficients measure the true coefficients. The effect of coefficient uncertainty depends on the exogenous variables. Since the estimated coefficients are multiplied by the exogenous variables χ_t in the computation of forecasts, the more exogenous variables deviate from their mean values, the greater is the forecast uncertainty.

When we construct a forecast of the $s_{t+1}^e = LEUSF$ by using different estimated equations, as we are doing, here, the computer output will give to us different forecast evaluation options (root mean squared error, mean absolute error, mean absolute percentage error, Theil inequality coefficient, etc.). The output will give to us the actual (s_t) and the forecasted value ($\hat{s}_t$) of the variable, with an F at the end (i.e., $LEUS$ and $LEUSF$). The reported forecast error statistic that we can look is the Root Mean Squared Error (*RMSE*) and it is computed as follows:

$$RMSE = \sqrt{\sum_{t=T+1}^{T+n} (\hat{s}_t - s_t)^2 / n} \tag{14}$$

This statistic (*RMSE*) depends on the scale of the dependent variable and it is used as a relative measure to compare forecasts for the same series across different models; the smaller the error, the better the forecasting ability of that model according to the RMSE criterion. Statistical programs offer dynamic and static forecasting. The *dynamic forecasting* is a multi-step forecast of $\hat{s}_{t+n}$. The *static forecasting* performs a series of one-step ahead forecast of the dependent variable $\hat{s}_{t+1}$. Both methods will always yield identical results in the first period of a multi-period forecast.[16] The *RMSEs* in our forecasting are for eq. (1) between 0.01526 (*LCS*) and 0.03476 (*LMS*); for eq. (3), they are from 0.01518 (*LCS*) to 0.03421 (*LMS*); and for eq. (7), from 0.01899 (*LCS*) to 0.03738 (*LMS*), which all reveal a very good forecasting.

Finally, there are currency forecasting services and many MNCs use forecasting services regularly. Forecasting is essential, but it is theoretically impossible; of course, it is better to have a view about the future instead ignoring it. A variety of opinions is generally useful when attempting to predict the future. Most forecasting services also provide added discipline to the forecasting process often missing within smaller corporate finance units. For example, the need to focus on the likely movement of an

[16] See, Kallianiotis (2013 and 2019c) for Unit Root (Stationarity) Test and for Cointegration Test, too.

exchange rate within a specific time interval is typically stressed within a forecasting unit while not within a business unit's planning horizon. A treasurer might also use a forecasting service because "it exists". If the treasurer does not use it, and guesses wrong on an exchange rate, the treasurer could be criticized or lose his job for not using available "expert advice".

VIII. CONCLUSION

The paper is using a fundamental forecasting model, a transfer function model, a *GARCH-M* model, and a *VAR* one and utilizes them for exchange rate forecasting. We start with the current spot exchange rate as a function of many macro-variables from both countries and we continue with the other models and end up with the *VAR* (spot and forward rates) as dependent variables with respect the other macro-variables (instruments of monetary policy) and lag values of the dependents. The theoretical equations are supported by the empirical results of seven different exchange rates. The past values of economic fundamentals are forecasting the future spot rate and forward rate. There is no doubt that the economic fundamentals of the two economies determine the future spot rate. In our economy, "We just follow the markets, the 'experts', the Illuminati, and the elites."[17] (*Sic*). Undoubtedly, uncertainty exists

[17] Lastly, we (especially Greeks) must be aware that we are undergoing changes in our financial, economic, geopolitical, cultural, political, technological, spiritual, and risk contexts and we must be sensitive and act with attention to these inhumane changes. Christian Orthodox Russia is not an enemy of the West the controlled heretic and atheist West is actually an enemy for Russia and the rest of the world. Atheist and Muslim Asia may be proven to be a future "enemy" for the entire West, the EU and the U.S. In 2016, with the new President in the U.S., Donald Trump, there was some hope for Europe and the entire world because he has some values different than the corrupted establishment of professional ignorant politicians. We cannot be opportunists and we cannot be danger-speakers, but realists, altruists, humanists, and truthful. "From the start, the construction of Europe was an extravagant political idea designed to imprison the nations of Europe into an 'ever closer' union of states." The best choice will be to reassess the need to move forward with the union or to hold back. Holding back might preserve whatever remains of each nation's sovereignty, language, and culture. We do not need any type of integrations or common currency and of course we do not want to have a supra-nationality, as a minority of people (and they are non-Europeans) believes, but it has louder voice, powerful control, and global influence than the majority. In recent years, citizens of Greece, Europe, and of the U.S. have shown their disappointment in and apprehensions for whom to vote. They try to elect the least evil in their questionable, corrupted, unethical, immoral, and deceptive "democracies". The elected representatives are unable to act in favor of their countries' interest. Their corruptive practices have become a national way of life. In EU there are different Europeanized domestic parties that all have the same beliefs and objectives, to ignore their countries; and they have created a class of citizens through favoritism and job offering to them that these voters support and fight for these parties. Territorial changes and political upheavals, as well as a public sense of lost identity and a public loss of faith in the government and all their leaders have become citizens' everyday problems. Euro-communism is doing relatively better in EU, now, (and in Greece these atheists anti-Greece traitors are in government for forty years terrorizing businesses, universities, and individuals) than in Russia, in the past. All these can have a profound negative effect on individual member-nations and on the current interdependence between the EU and its members. But, the current problem is to recover from the financial crisis and its recession, from the suspicious COVID-19, the possible new banking crisis, and to send illegal immigrants and foreign anarchists back to their countries of origin, which seems as a very long process. Of course, Greeks have a big obligation towards their history and ancestors, who have created their civilization, the Hellenic-Orthodox one, which is unique on earth for those who have cultivated their intellect and are able to do objective comparisons. Greeks have no right to be like the rest of the Europeans because they have the obligation to be perfect. God gave to them the ancient moral philosophers and the revelation in their

always in the forecasting of any economic variables, political and social ones, due to unanticipated public policies (monetary, fiscal, and trade), suspicious official data, and other "innovations" in our financial markets and institutions, plus the new philosophies (i.e., liberalism, lack of ethics, perversions, CRT, DEI, AI, wars, BRICS, forced globalization, etc.), and value system in our markets, societies, and way of living (back to middle ages)..

Hopefully, with a correct specification and a careful evaluation the economic fundamental, econometric forecasting can be an efficient method of forecasting the exchange rates. The seven exchange rates that are estimated give a very good forecasting mostly for the spot and one forward exchange rate (the LEUF) for these countries. Of course, in our dynamic, complex, computerized, and globalized markets, it is difficult to forecast any variable correctly. The monetary policy, the fiscal policy, the trade policy, the growth of the economies, the interest rates, and many other macro-variables in both countries are all affecting the exchange rate because it is a relative price (i.e., $/€ or $/£, etc.). We need some ethical and moral public policies,[18] which will maximize social welfare and the wellbeing of the citizens and not to maximize (with artificial bubbles) temporarily the market values of some financial variables, which are not related with the real variables and the true social values; but cause inflations (deterioration of purchasing power), high risk to investors and consumers, and unjustifiable volatility to exchange rates, as Graphs A1 and A2 reveal.

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language. These obligations are enormous, and their destiny is to reach perfection and enlighten the rest of Europe and the world, together with the other Eastern European nations and mostly with its spiritual daughter, Russia. The war of the West against Russia in Ukraine is a very dangerous criminal act of our controlled pseudo-leaders with the army of the Illuminati, the NATO. See, John N. Kallianiotis, *The European Union and its Debt Crises: The Deception of the Greeks*, Hauppauge, N.Y.: Nova Science Publishers, August 2018, ISBN: 978-1-53614-067-5. https://novapublishers.com/shop/the-european-union-and-its-debt-crises-the-deception-of-the-greeks/ . See also, De Ruiter (2018) and Mearsheimer and Walt (2007)..

[18] See, Kallianiotis (2023).

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Appendix

Table A1: Exchange Rate Forecasting, Combining Eq. (1) and (5)

Variables	*eus*	*ms*	*cs*	*uks*	*sws*	*js*	*as*
C	0.030	-1.809	1.023***	0.494	0.832	-4.926***	0.467
	(0.220)	(1.257)	(0.182)	(0.818)	(1.214)	(1.118)	(0.643)
$m_{t-1} - m_{t-1}^*$	0.005	0.131**	-0.393***	-0.141	0.069	-0.094	-0.113
	(0.028)	(0.066)	(0.038)	(0.093)	(0.162)	(0.200)	(0.115)
$y_{t-1} - y_{t-1}^*$	0.065**	0.294	0.001	-0.154	0.290	0.036	0.178
	(0.031)	(0.229)	(0.047)	(0.229)	(0.381)	(0.188)	(0.128)
$i_{t-1} - i_{t-1}^*$	0.003	-0.003***	-0.002	-0.020***	-0.001	-0.005	-0.005
	(0.007)	(0.001)	(0.002)	(0.004)	(0.008)	(0.007)	(0.005)
$p_{t-1} - p_{t-1}^*$	0.028	0.642***	-0.459***	-0.370*	-0.063	-0.048	-0.052
	(0.272)	(0.175)	(0.109)	(0.223)	(0.312)	(0.247)	(0.275)
$u_{t-1} - u_{t-1}^*$	0.001	-	-	-	-	-	-
	(0.005)						
$AR(1)$	0.979***	0.968***	0.986***	0.967***	0.995***	0.972***	0.981***
	(0.011)	(0.022)	(0.008)	(0.014)	(0.008)	(0.013)	(0.011)
$MA(1)$	0.168***	0.352***	-0.128***	0.293***	0.143*	0.265***	0.394***
	(0.052)	(0.056)	(0.031)	(0.053)	(0.079)	(0.044)	(0.044)
R^2	0.971	0.992	0.984	0.970	0.979	0.966	0.979
SER	0.024	0.035	0.015	0.021	0.023	0.024	0.024
F	1,083.2	5,716.5	4,215.8	1,682.7	1,507.1	1,273.3	2,568.2
$D-W$	1.962	1.926	2.013	2.000	1.982	1.920	2.004
N	264	322	480	374	232	320	393
$RMSE$	0.02358	0.03476	0.01526	0.02072	0.02265	0.02363	0.02355

Note: *eus* = ln of EU spot ($/€), *ms* = ln of Mexico spot ($/MP), *cs* = ln of Canada spot ($/C$), *uks* = ln of U.K. spot ($/£), *sws* = ln of Swiss spot ($/SF), *js* = ln of Japan spot ($/¥), *as* = ln of Australia spot ($/A$), s_t= ln of spot exchange rate, C = constant term, $m_{t-1} - m^*_{t-1}$= money differential, $y_{t-1} - y^*_{t-1}$ =income differential, $i_{t-1} - i^*_{t-1}$ = interest rate differential, $p_{t-1} - p^*_{t-1}$ = price differential, $u_{t-1} - u^*_{t-1}$= unemployment differential, $AR(1)$ = autoregressive one process, $MA(1)$ = moving average one process, R^2 = R-squared, SER = S.E. of regression, $D-W$ = Durbin-Watson statistic, F = F statistic, N = number of observations, $RMSE$ = Root Mean Squared Error, *** significant at the 1% level, ** significant at the 5% level, and * significant at the 10% level.
Source: *Economagic.com*, *Bloomberg*, and *Eurostat.*

Table A2: Exchange Rate Forecasting, Combining Eq. (3) and (5)

Variables	*eus*	*ms*	*cs*	*uks*	*sws*	*js*	*as*
C	0.903	4.245	1.531*	-0.988	-8.017***	-7.781	0.611
	(3.562)	(3.487)	(0.858)	(1.594)	(2.500)	(6.940)	(2.504)
m_{t-1}	0.048	0.215	-0.259***	-0.221	0.173	-0.105	0.120
	(0.218)	(0.331)	(0.080)	(0.148)	(0.193)	(0.243)	(0.195)
m^*_{t-1}	-0.006	-0.132*	0.412***	0.169	0.022	0.329	0.092
	(0.155)	(0.070)	(0.039)	(0.110)	(0.168)	(0.622)	(0.135)
y_{t-1}	-0.185	0.230	-0.074	0.042	0.180	0.013	0.010
	(0.326)	(0.518)	(0.122)	(0.267)	(0.417)	(0.256)	(0.303)
y^*_{t-1}	-0.076**	-0.247	-0.004	0.068	0.046	0.015	-0.365**
	(0.032)	(0.264)	(0.070)	(0.225)	(0.421)	(0.232)	(0.185)
i_{t-1}	-0.004	-0.021	-0.001	-0.002	-0.003	-0.002	-0.005
	(0.011)	(0.015)	(0.004)	(0.008)	(0.009)	(0.009)	(0.008)
i^*_{t-1}	-0.007	0.003***	0.002	0.030***	-0.003	0.024*	0.005
	(0.008)	(0.001)	(0.003)	(0.004)	(0.012)	(0.012)	(0.006)
p_{t-1}	0.245	-0.804	-0.688***	-0.211	0.322	-0.187	0.041
	(0.466)	(0.845)	(0.208)	(0.331)	(0.479)	(0.416)	(0.447)
p^*_{t-1}	-0.017	-0.445**	0.486***	0.440*	0.439	0.058	0.366
	(0.277)	(0.220)	(0.102)	(0.268)	(0.403)	(0.293)	(0.369)
u_{t-1}	-0.001	-	-	-	-	-	-
	(0.008)						
u^*_{t-1}	0.006	-	-	-	-	-	-
	(0.017)						
$AR(1)$	0.977***	0.954***	0.984***	0.963***	0.961***	0.973***	0.976***
	(0.014)	(0.021)	(0.008)	(0.016)	(0.021)	(0.012)	(0.012)
$MA(1)$	0.166***	0.377***	-0.133***	0.266***	0.132	0.267***	0.402***
	(0.054)	(0.061)	(0.032)	(0.053)	(0.086)	(0.045)	(0.047)
R^2	0.972	0.992	0.984	0.971	0.980	0.966	0.979
SER	0.024	0.035	0.015	0.021	0.023	0.024	0.024
F	661.83	3,708.5	2,690.26	1,113.4	962.3	804.9	1,634.6
$D-W$	1.969	1.896	2.021	2.003	1.983	1.912	1.998
N	264	322	480	374	232	320	393
$RMSE$	0.02344	0.03421	0.01518	0.02023	0.02241	0.02356	0.02342

Note: See, Table A1. m_{t-1} = lagged value of ln of M^s in U.S. and m^*_{t-1} = lagged value of ln of M^{*s} in the foreign country.

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Source: See, Table A1.

Table A3: Exchange Rate Forecasting, the GARCH-M Model, Eq. (7)

Variables	*eus*	*ms*	*cs*	*uks*	*sws*	*js*	*as*
C	-8.792	-11.376	-5.972**	-10.057	-8.160***	26.443	-0.002
	(75.302)	(14.582)	(3.043)	(103.169)	(2.333)	(48.879)	(2.305)
m_{t-1}	0.591**	-0.628	-0.416***	0.027	0.012	-0.916	0.130
	(0.238)	(1.182)	(0.118)	(0.185)	(0.153)	(2.031)	(0.185)
m^*_{t-1}	-0.009	-0.016	0.455***	0.001*	0.184	1.632	0.020
	(0.016)	(0.267)	(0.042)	(0.001)	(0.144)	(4.871)	(0.129)
y_{t-1}	-0.102	0.253	1.306***	-0.398	-0.160	-1.174	0.223
	(0.222)	(2.051)	(0.104)	(0.298)	(0.398)	(1.562)	(0.293)
y^*_{t-1}	-0.052*	0.320	0.039*	0.395	0.369	-2.302	-0.327*
	(0.028)	(1.049)	(0.023)	(0.275)	(0.377)	(1.586)	(0.170)
i_{t-1}	0.007	-0.015	-0.001	0.003	-0.011	0.006	-0.002
	(0.010)	(0.063)	(0.002)	(0.008)	(0.008)	(0.079)	(0.007)
i^*_{t-1}	-0.005	0.002	0.001	0.023***	0.013	0.024	0.006
	(0.010)	(0.004)	(0.002)	(0.004)	(0.015)	(0.200)	(0.004)
p_{t-1}	0.135	2.004	-1.589***	0.077	0.117	2.097	0.048
	(0.511)	(3.262)	(0.242)	(0.391)	(0.487)	(3.091)	(0.384)
p^*_{t-1}	0.008	-0.779	0.222***	0.655***	0.443	-3.150	0.017
	(0.234)	(1.302)	(0.064)	(0.228)	(0.398)	(2.424)	(0.329)
u_{t-1}	-0.002	-	-	-	-	-	-
	(0.004)						
u^*_{t-1}	0.001	-	-	-	-	-	-
	(0.013)						
$AR(1)$	0.999***	0.970***	0.999***	0.999***	0.897***	0.849***	0.977***
	(0.008)	(0.111)	(0.001)	(0.006)	(0.035)	(0.303)	(0.011)
$MA(1)$	0.237***	0.337	-0.142***	0.240***	0.144	0.152	0.386***
	(0.003)	(0.248)	(0.044)	(0.065)	(0.105)	(0.552)	(0.053)
			Variance Equation				
C	0.001	0.002	-0.001**	0.001*	0.001	0.003	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.005)	(0.001)
ε^2_{t-1}	-0.071**	0.148	-0.006**	0.086**	0.149*	0.150	0.144***
	(0.035)	(0.093)	(0.003)	(0.041)	(0.093)	(0.335)	(0.033)
ε^2_{t-2}	0.236***	-	-	-	-	-	-
	(0.070)						
σ^2_{t-1}	0.312**	0.598*	1.016***	0.785***	0.599*	0.600	0.826***
	(0.129)	(0.365)	(0.004)	(0.096)	(0.334)	(0.568)	(0.054)
σ^2_{t-2}	0.422***	-	-	-	-	-	-
	(0.142)						
R^2	0.970	0.991	0.976	0.971	0.979	0.924	0.979
SER	0.025	0.038	0.019	0.021	0.023	0.036	0.024
$D-W$	2.150	2.161	1.997	1.950	1.976	1.995	1.979
N	263	321	477	371	231	319	392
$RMSE$	0.02401	0.03738	0.01899	0.02042	0.02218	0.03546	0.02348

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Note: See, Table A1. ε_{t-i}^2 = the lag of the squared residual (the ARCH term) and σ_{t-j}^2 = the previous forecasts variance (the GARCH term).
Source: See, Table A1.

Table A4: Exchange Rate Forecasting, VAR Estimation, Eqs. (8 and 9)

Variables	*eus*	*euf*	*eus*	*euf*
s_{t-1}	0.512***	0.510***	0.467***	0.488***
	(0.140)	(0.181)	(0.137)	(0.176)
s_{t-2}	0.192*	0.245*	0.433***	0.438**
	(0.113)	(0.146)	(0.138)	(0.177)
s_{t-3}	-	-	-0.377***	-0.328***
			(0.110)	(0.142)
f_{t-1}	0.643***	0.566***	0.671***	0.566***
	(0.114)	(0.147)	(0.110)	(0.142)
f_{t-2}	- 0.390***	-0.380***	-0.434***	-0.421***
	(0.123)	(0.159)	(0.118)	(0.152)
f_{t-3}	-	-	0.170	0.177
			(0.120)	(0.154)
C	0.018*	0.035***	0.032***	0.042***
	(0.010)	(0.013)	(0.012)	(0.015)
$i_{FF\ t-1}$	-	-	-0.001	-0.001
			(0.001)	(0.002)
i_{OND}^*	-	-	0.001	0.001
			(0.002)	(0.003)
t	- 0.001*	-0.001***	-0.001**	-0.001***
	(0.01)	(0.001)	(0.001)	(0.001)
R^2	0.959	0.935	0.963	0.941
SEE	0.021	0.027	0.020	0.025
F	942.234	580.562	571.631	347.556
N	209	209	207	207

Note: See, Table A1. *eus* = ln of EU spot ($/€), *euf* =ln of EU forward rate ($/€), i_{FF}= effective federal funds rate and i_{OND}^* = ECB overnight deposit rate.
Source: See, Table 1.

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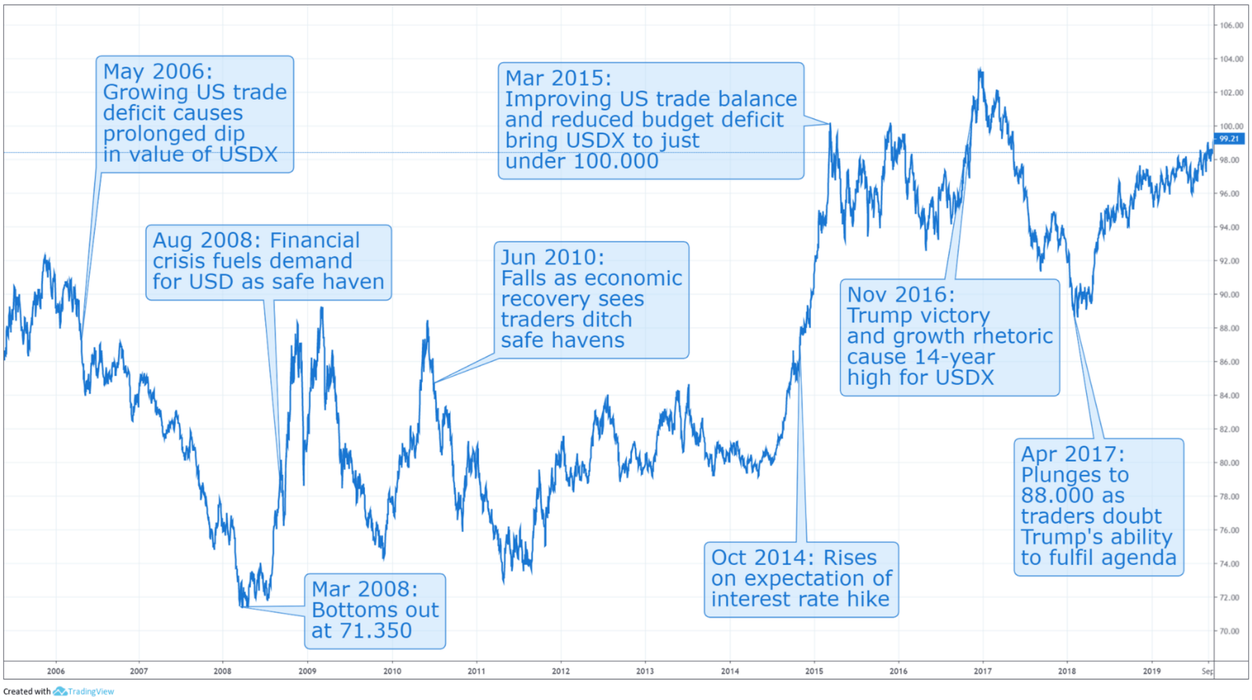

Graph A1: The U.S. Dollar Index

Note: The US Dollar Index was started by the Federal Reserve in 1973 and has been managed by ICE Futures US since 1985. It compares the value of the US Dollar against six currencies used by major US trade partners – the Euro (EUR), Japanese Yen (JPY), Pound Sterling (GBP), Canadian Dollar (CAD), Swedish Krona (SEK) and Swiss Franc (CHF).
Source: US Dollar Index Futures Streaming Chart. https://www.investing.com/currencies/us-dollar-index-streaming-chart and https://www.investing.com/currencies/us-dollar-index

Graph A2: EUR/USD continues oscillation below 1.0750 amid a quiet market mood ahead of US Inflation

Source: [EUR/USD continues oscillation below 1.0750 amid a quiet market mood ahead of US Inflation (fxstreet.com)]()

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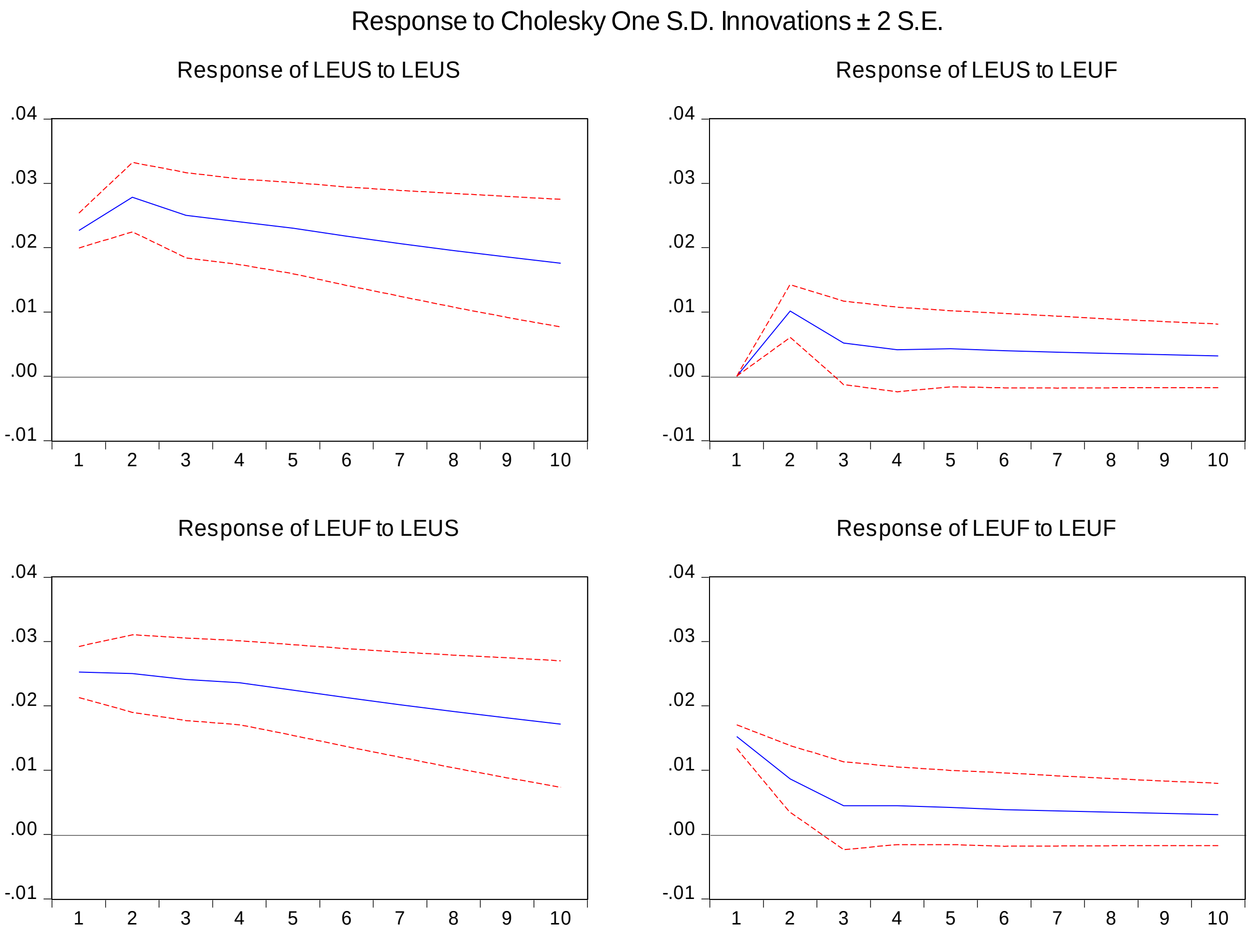

Figure A1: The Impulse Response Function

Source: VAR Estimations, Table A4.

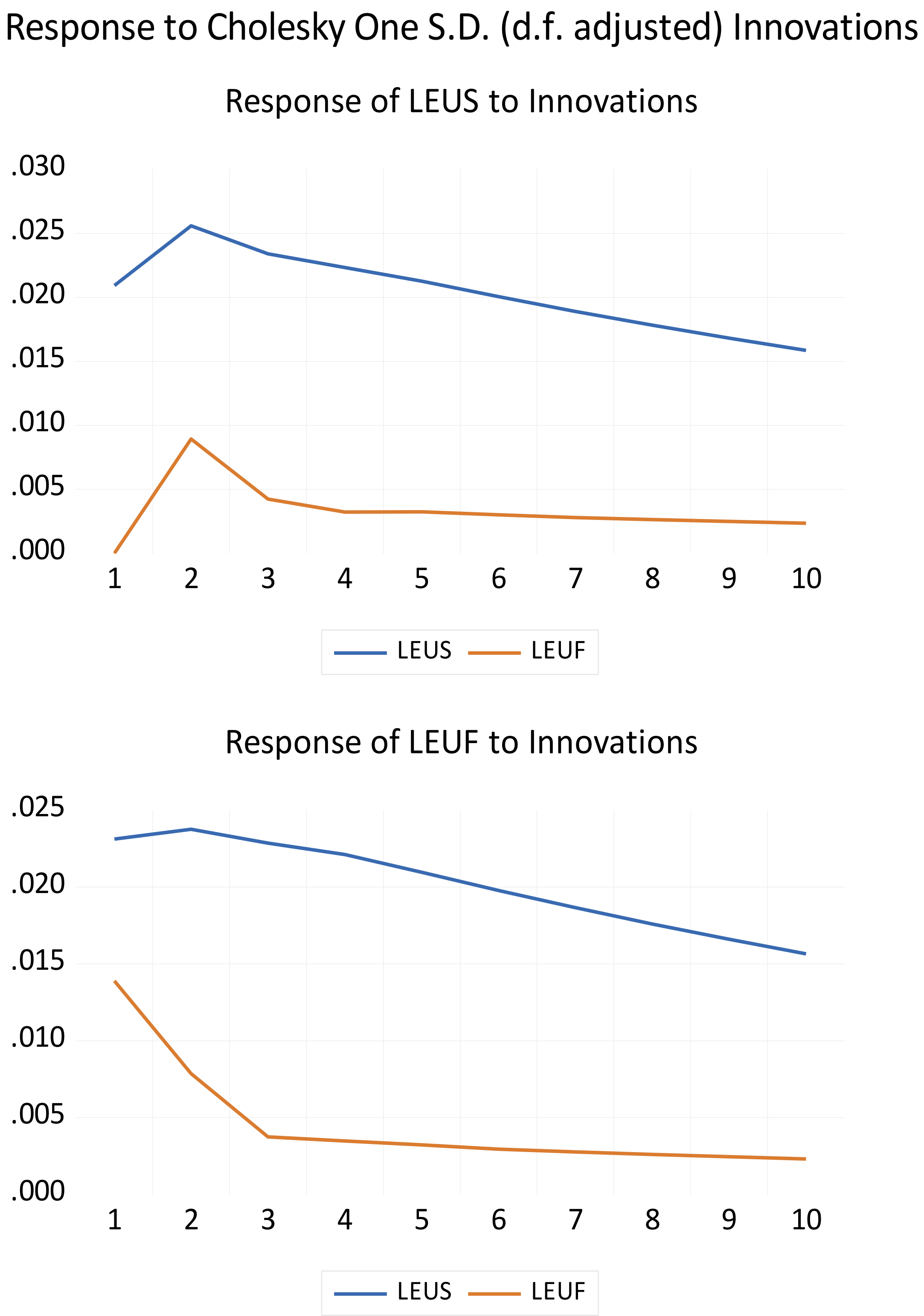

Figure A2: The Impulse Response Function

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Source: VAR estimation from Table A4

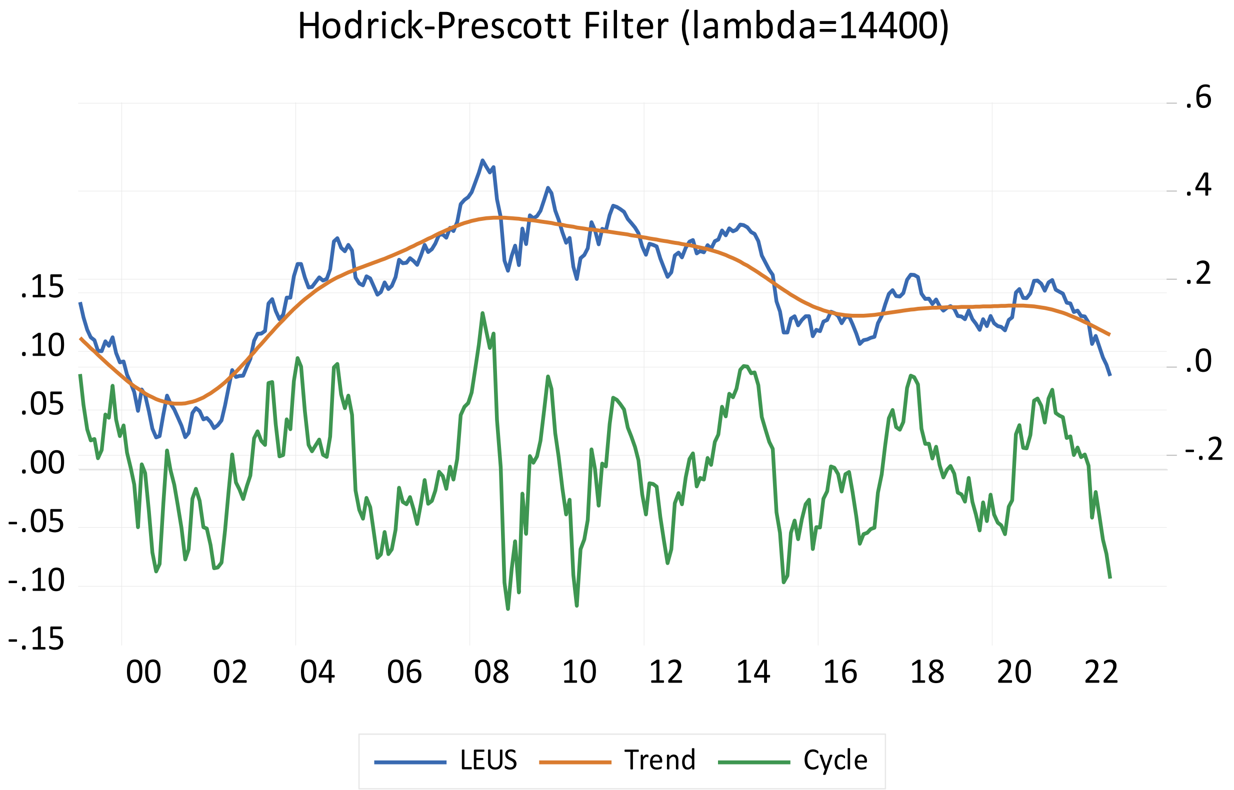

Figure A3: Long-Term Trend Smoothing of LEUS

Source: Estimation of eq. (3), Table A2.

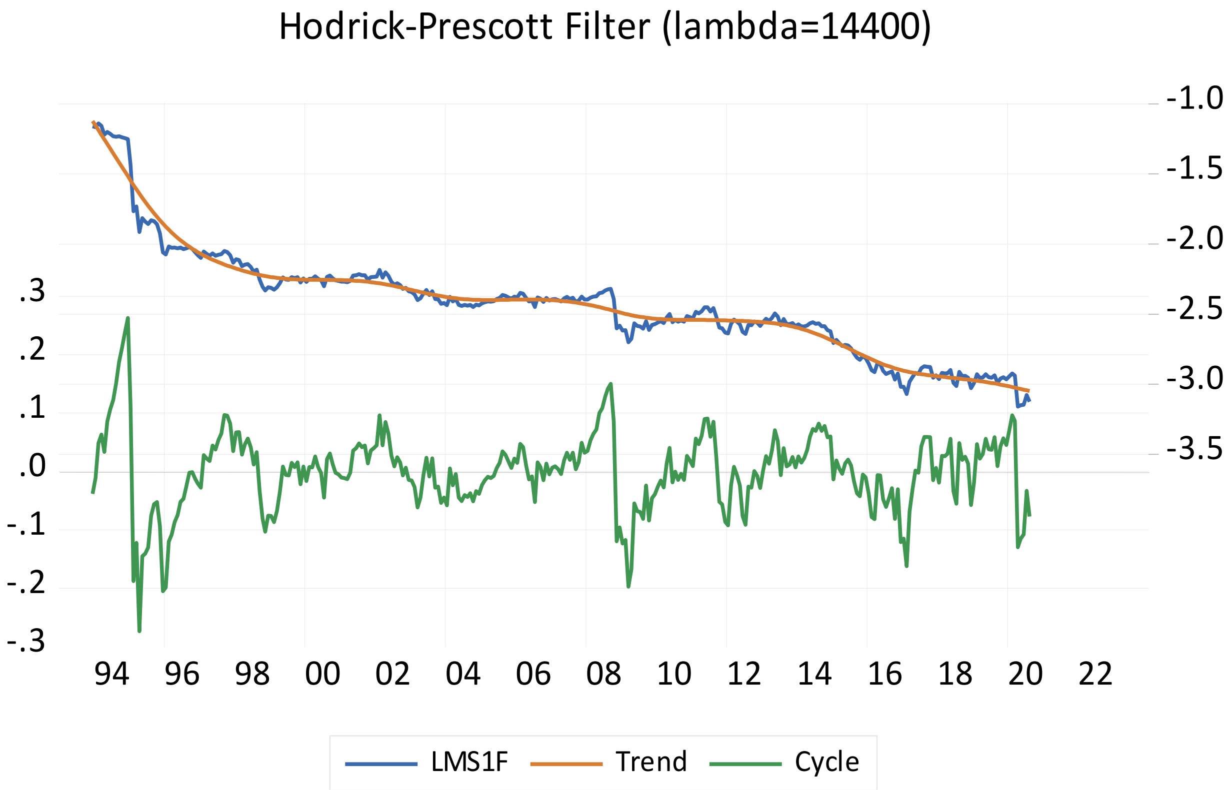

Figure A4: Long-Term Trend Smoothing of LMS

Source: See, Figure A3.

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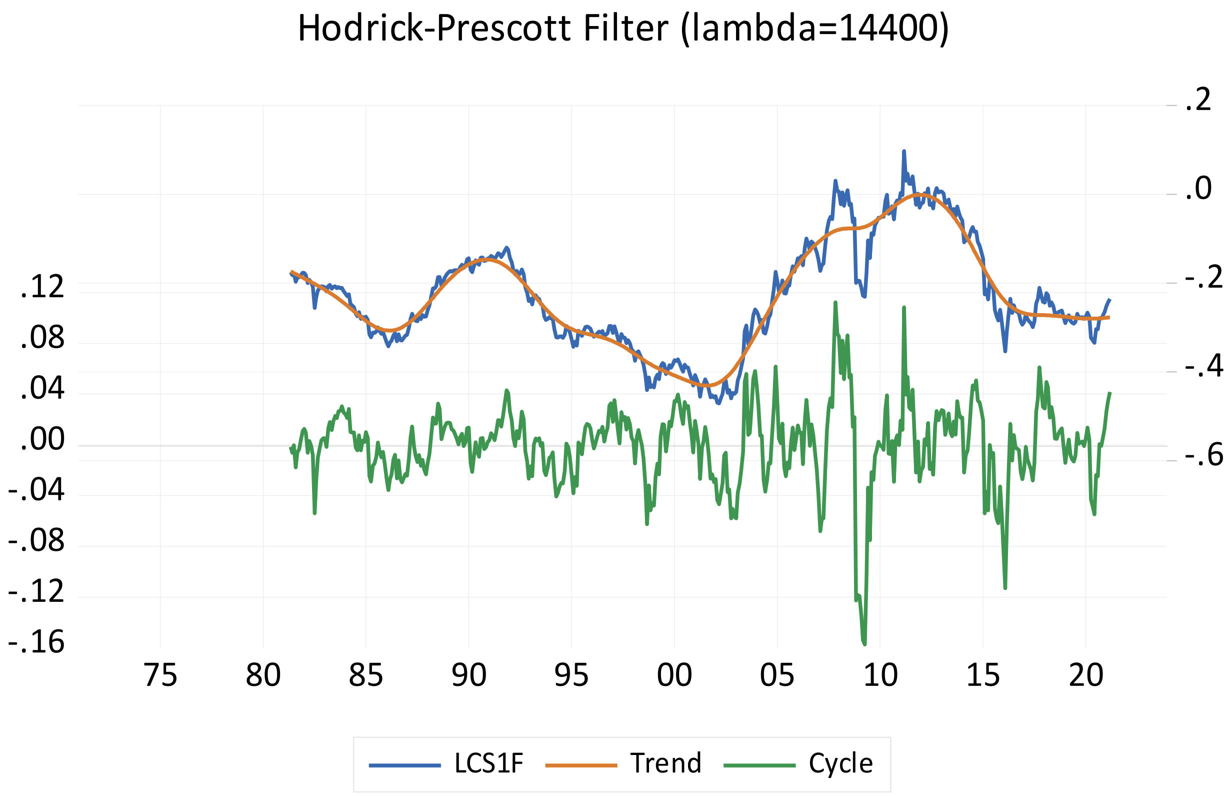

Figure A5: Long-Term Trend Smoothing of LCS

Source: See, Figure A3.

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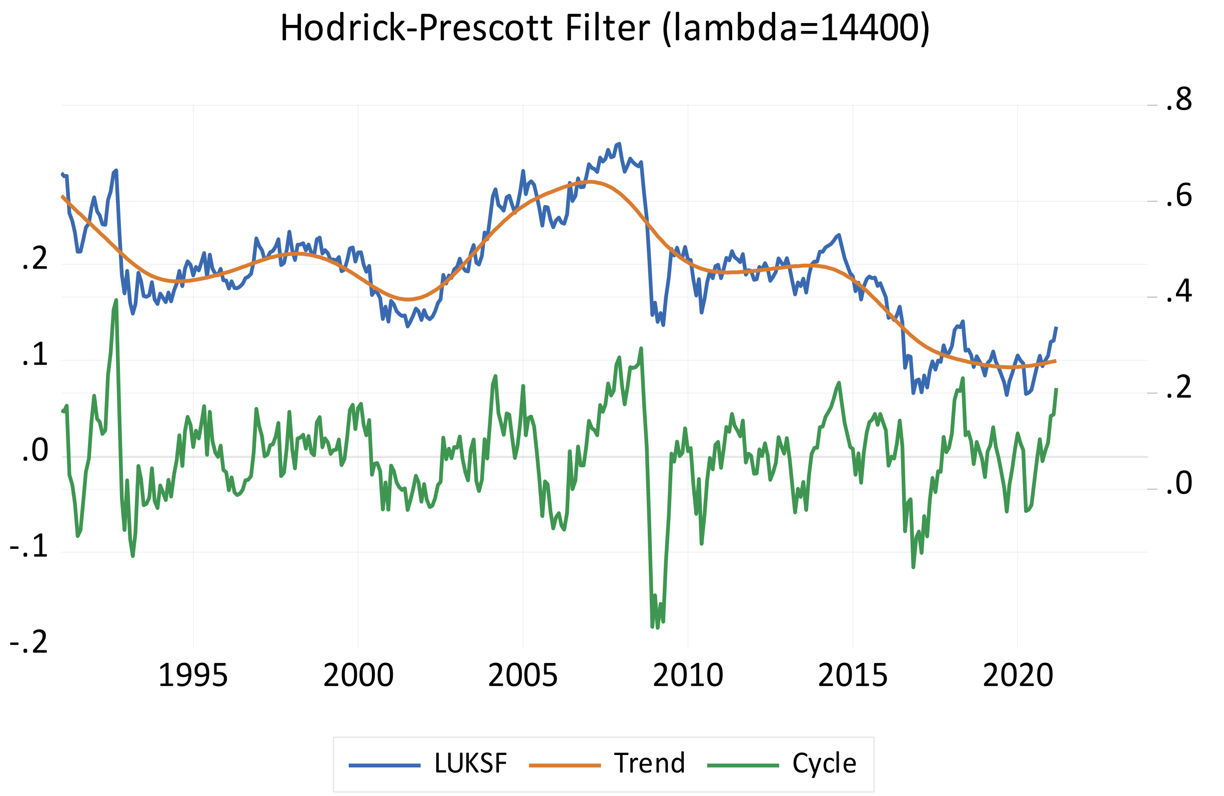

Figure A6: Long-Term Trend Smoothing of LUKS

Source: See, Figure A3.

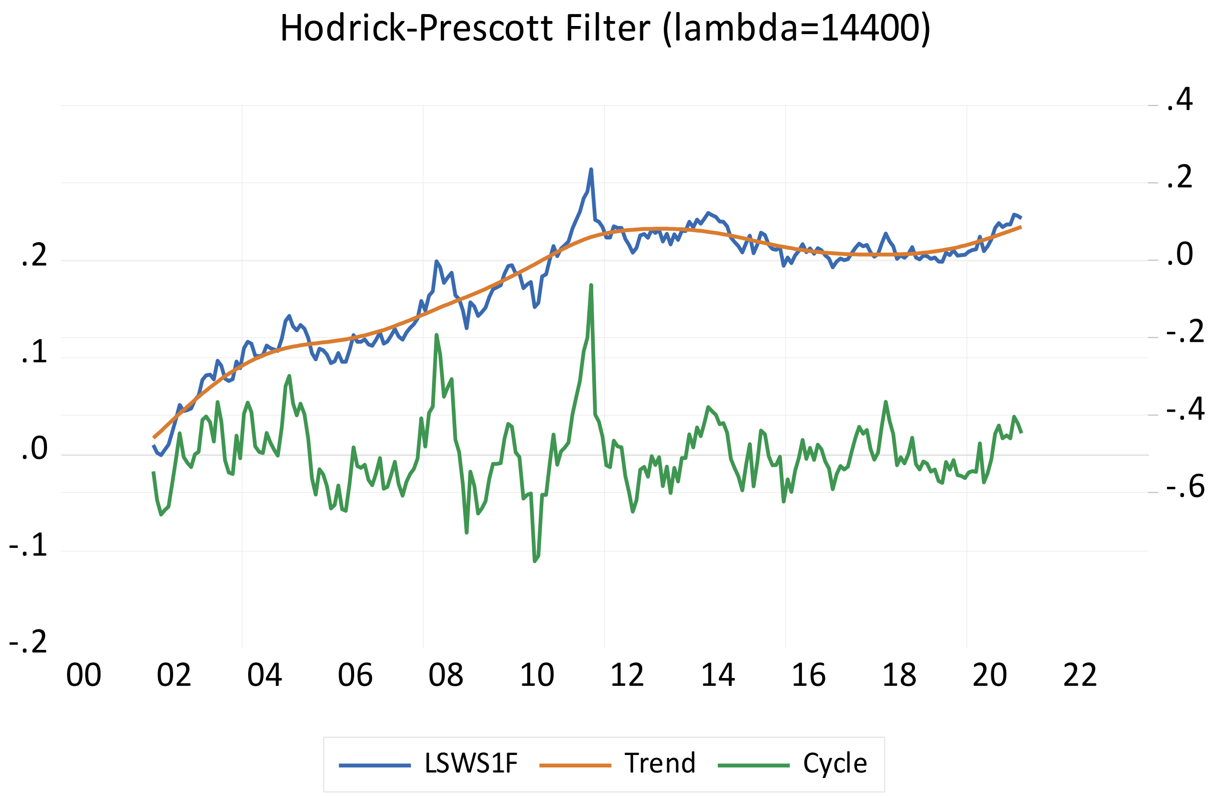

Figure A7: Long-Term Trend Smoothing of LSWS

Source: See, Figure A3.

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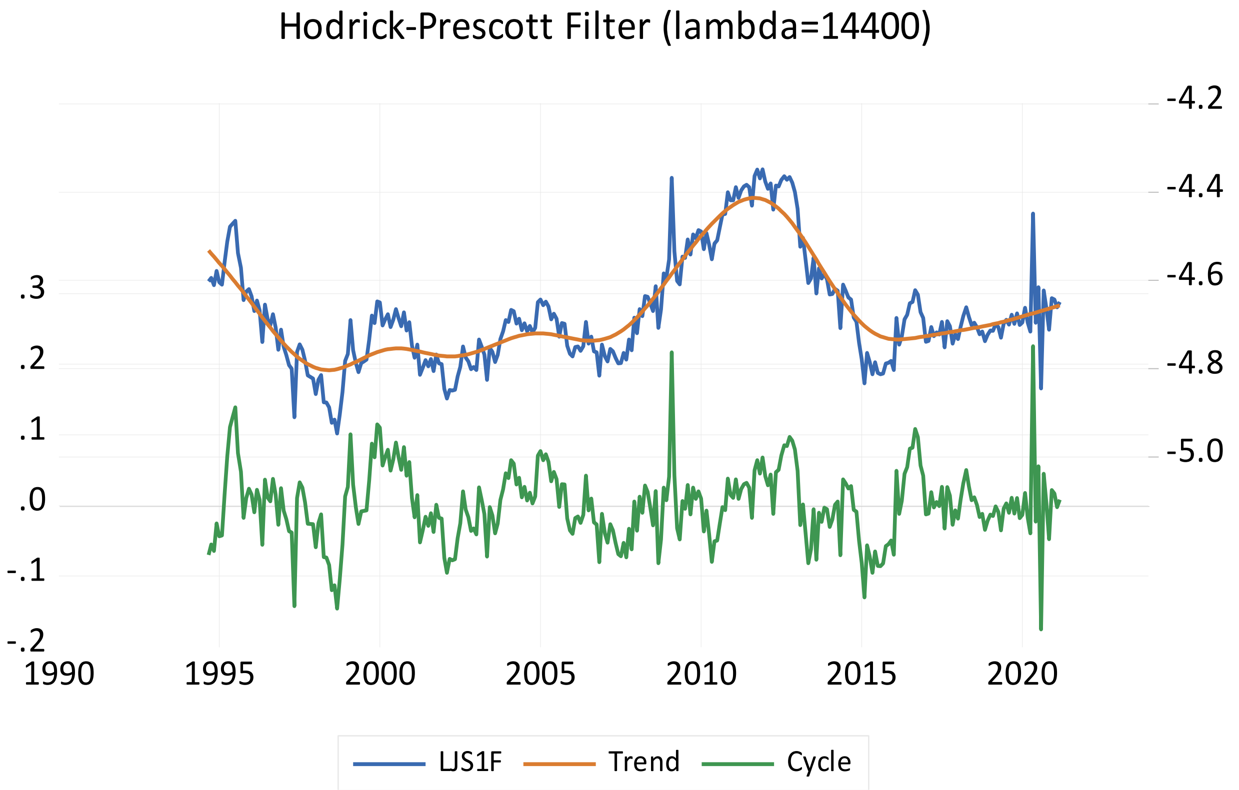

Figure A8: Long-Term Trend Smoothing of LJS

Source: See, Figure A3.

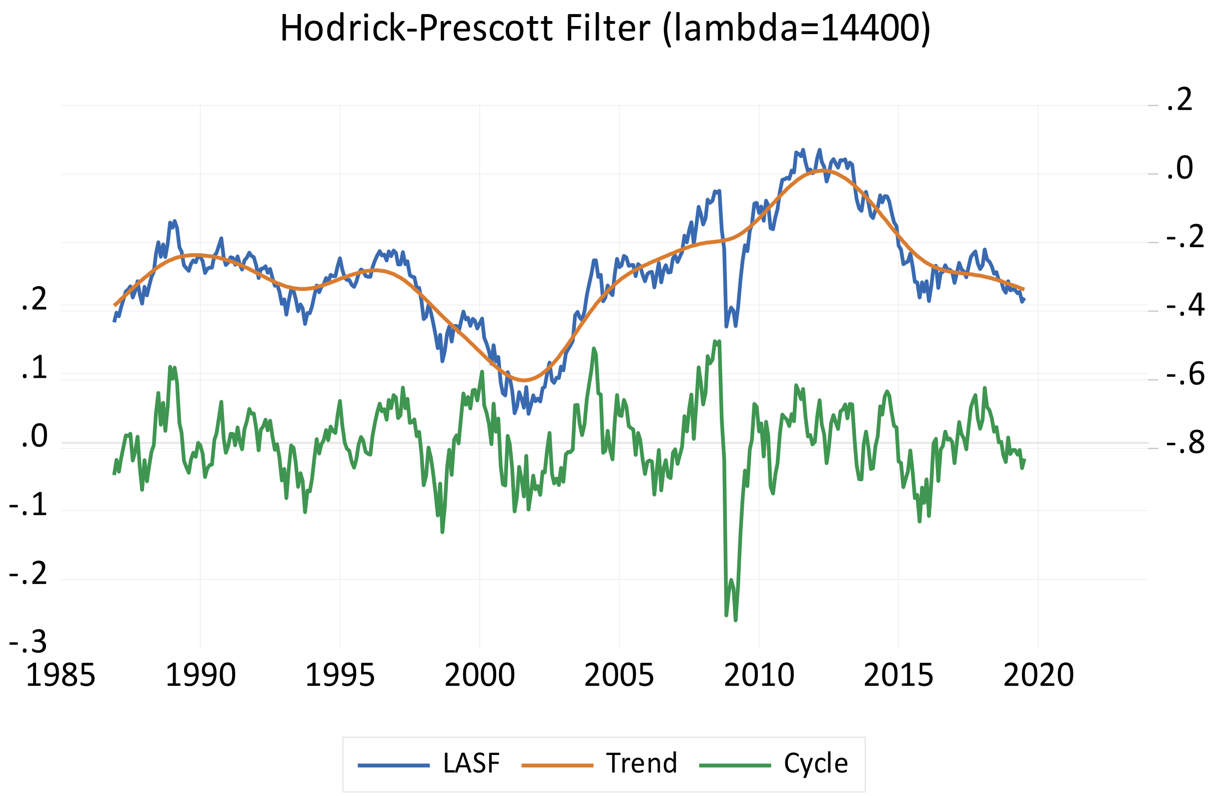

Figure A9: Long-Term Trend Smoothing of LAS

Source: See, Figure A3.