Vasilev, Aleksandar; Pavlov, Plamen; Rainov, Stefan; Kovatchev, Tsvetoslav

Research Report
Testing three models in international economics: The Purchasing Power Parity Model, the Interest Rate Parity Model and the Monetary Model: The case of the Turkish Lira and the US Dollar (1975-1999)

Suggested Citation: Vasilev, Aleksandar; Pavlov, Plamen; Rainov, Stefan; Kovatchev, Tsvetoslav (2002) : Testing three models in international economics: The Purchasing Power Parity Model, the Interest Rate Parity Model and the Monetary Model: The case of the Turkish Lira and the US Dollar (1975-1999), ZBW - Deutsche Zentralbibliothek für Wirtschaftswissenschaften, Leibniz-Informationszentrum Wirtschaft, Kiel und Hamburg

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Testing three models in international economics: The Purchasing Power Parity Model, the Interest Rate Parity Model and the Monetary Model: The case of the Turkish Lira and the US Dollar (1975-1999)

Aleksandar Vasilev
Plamen Pavlov
Stefan Rainov
Tsvetoslav Kovatchev
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CONCISE PROJECT SUMMARY

The goal of this empirical project is to test the validity of three economic models – The General Monetary, The Purchasing Power Parity and The Interest Rate Parity models in Turkey – basing on quarterly data for the period 1975 – 1999. The project takes into account the serious economic shocks that hit the Turkish economy in 1979 and 1994.

Different models are created and the variables are tested for Significance, Serial Correlation, Unit Root and Cointegration. The tests used throughout the project are: Dickey Fuller, Augmented Dickey Fuller, Breusch-Godfrey LM Test for cointegration and Johansen Test.

The outputs of the tests are presented to support the conclusions made throughout the test. The basic findings made are that for Turkey the three models: The General Monetary Model, The Purchasing Power Parity Model and The Interest Rate Parity hold for the time period 1975 – 1999.
I. Introduction

Project goal:

The empirical project will test the validity of three alternative economic models that describe the behavior of the exchange rate of the Turkish Lira against the US dollar during the period from 1975 to 1999 including. The General Monetary Model describes the effects of changes in money supply on the exchange rate. The Purchasing Power Parity Model establishes the relationship between the inflation rate and the exchange rate. The Interest Rate Parity Model captures the effect of the change in relative interest rates on the exchange rate.

A Brief Overview Of The Turkish Economy

SOURCES: 2001 CIA WORLD FACTBOOK
BCSIA PUBLICATIONS

Turkey's dynamic economy is a complex mix of modern industry and commerce along with traditional agriculture that still accounts for nearly 40% of employment. It has a strong and rapidly growing private sector, yet the state still plays a major role in basic industry, banking, transport, and communication. Textiles and clothing is the most important industry and the major exporter.

The years considered in the project include the so-called second oil price shock in 1979. It had a significant impact on the Turkish economy. The shock affected the macroeconomic variables: GDP, unemployment, inflation, and thus changed the overall structure of the Turkish economy.

In recent years the economic situation has been marked by erratic economic growth and serious imbalances. Real GNP growth has exceeded 6% in most years, but this strong expansion was interrupted by sharp declines in output in 1994 and 1999. Meanwhile the public sector fiscal deficit has regularly exceeded 10% of GDP - due in large part to the huge burden of interest payments, which account for more than 40% of central government spending, while inflation has remained in the high double-digit range.

Perhaps because of these problems, foreign direct investment in Turkey remains low - less than $1 billion annually. Prospects for the future are improving, however, because the Ecevit government since June 1999 has been implementing an IMF-supported reform program, including a tighter budget, social security reform, banking reorganization, and accelerated privatization. As a result, the fiscal situation is greatly improved and inflation has dropped below 40% - the lowest rate since 1987.
II. Variables used

Dummy Variables

Basing on the data about the Turkish economy we will use two dummy variables:

- D 79 - The effect of oil price shocks
  (1975 - 1978) = 0
  (1979 - 1999) = 1
- D 94 - The recession of 1994
  (1975 - 1993) = 0
  (1994 - 1999) = 1

The data used throughout the analysis are quarterly, for the period years 1975 and 1999. Data are defined as follows:

- NER - Nominal exchange rate (TRL/ USD)
- M1 - Money supply (Turkey)
- P_TUR - Price index (Turkey)
- INT_TUR - Discount Rate (Turkey)
- P_USA - Price index (USA)
- INT_USA - Discount Rate (USA)

The variables computed and included in the models are:

- LOGNER - Logarithm on the nominal exchange rate
- DLOGNER = LOGNER - LOGNER1
- LOGM1 - Logarithm of the Money Supply
- DLOGM1 = LOGM1 - LOGM1_1
- LOGP_TUR - Logarithm price index Turkey
- LOGP_USA - Logarithm price index USA
- LOGDIFP = LOGP_TUR - LOGP_USA
- LOGDIFP1 = LOGP_TUR1 - LOGP_USA1
- DLOGDIFP = LOGDIFP - LOGDIFP1
- SRADJPPP = LOGDIFP1 - LOGNER1
- LOGINT_TUR - Logarithm Discount Rate Turkey
- LOGINT_USA - Logarithm Discount Rate USA
- LOGDIFINT = LOGINT_TUR - LOGINT_USA
- LOGDIFINT1 = LOGINT_TUR1 - LOGINT_USA1
- DLOGDIFINT = LOGDIFINT - LOGDIFINT1
- SRADJIRP = LOGDIFINT1 - LOGNER1
- SRADJM1 = LOGM1_1 - LOGNER1
III. Tests

1. Purchasing power parity

Unit Root Test

A. Unit Root Test on LOGNER

From the graph it can be seen that the data on LOGNER is non-stationary with a time trend.

UNIT ROOT LOGNER

Ho: $\rho=1 \Rightarrow$ Unit Root Exists
Ha: $\rho<1 \Rightarrow$ No Unit Root Exists

ADF Test Statistic: -1.411951

1% Critical Value*:

$-4.0550$

5% Critical Value:

$-3.4561$

10% Critical Value:

$-3.1536$

*MacKinnon critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOGNER)
Method: Least Squares
Date: 12/11/02   Time: 20:24
Sample(adjusted): 1975:4 1999:4
Included observations: 97 after adjusting endpoints

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOGNER(-1)</td>
<td>-0.038829</td>
<td>0.027500</td>
<td>-1.411951</td>
<td>0.1613</td>
</tr>
<tr>
<td>D(LOGNER(-1))</td>
<td>0.068762</td>
<td>0.102908</td>
<td>0.668191</td>
<td>0.5057</td>
</tr>
<tr>
<td>D(LOGNER(-2))</td>
<td>-0.106975</td>
<td>0.103115</td>
<td>-1.037430</td>
<td>0.3023</td>
</tr>
<tr>
<td>C</td>
<td>0.132105</td>
<td>0.049781</td>
<td>2.653701</td>
<td>0.0094</td>
</tr>
<tr>
<td>@TREND(1975:1)</td>
<td>0.005115</td>
<td>0.002992</td>
<td>1.709598</td>
<td>0.0907</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.098650</td>
<td>Mean dependent var</td>
<td>0.108253</td>
<td></td>
</tr>
<tr>
<td>Adjusted R-squared</td>
<td>0.059461</td>
<td>S.D. dependent var</td>
<td>0.095859</td>
<td></td>
</tr>
<tr>
<td>S.E. of regression</td>
<td>0.092965</td>
<td>Akaike info criterion</td>
<td>-1.863012</td>
<td></td>
</tr>
</tbody>
</table>
Performing the Augmented Dickey-Fuller Unit Root Test, we conclude that there is a unit root because at 5% level of significance $t > t^*$

B. Unit Root Test on LOGDIFP
From the graph it can be seen that the data on LOGDIFP is non-stationary with a time trend.

UNIT ROOT LOGDIFP

Ho: $\rho=1$ => Unit Root Exists
Ha: $\rho<1$ => No Unit Root Exists

<table>
<thead>
<tr>
<th>ADF Test Statistic</th>
<th>1% Critical Value*</th>
<th>5% Critical Value</th>
<th>10% Critical Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1.232996</td>
<td>-4.0550</td>
<td>-3.4561</td>
<td>-3.1536</td>
</tr>
</tbody>
</table>

*MacKinnon critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOGDIFP)
Method: Least Squares
Date: 12/11/02  Time: 20:56
Sample(adjusted): 1975:4 1999:4
Included observations: 97 after adjusting endpoints

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
</table>

\`

7
After performing the Dickey-Fuller Unit Root Test, we conclude that there is a unit root because $t > t^*$.

### C. UNIT ROOT TEST ON DLOGNER AND DLOGDIFP

As both LOGNER and LOGDIFP are Random Walks we correct for that using differencing. Thus, we obtain DLOGNER and DLOGDIFP. We test the new variables for unit root.

#### UNIT ROOT FOR DLOGNER

<table>
<thead>
<tr>
<th>ADF Test Statistic</th>
<th>1% Critical Value*</th>
<th>5% Critical Value</th>
<th>10% Critical Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>-4.757838</td>
<td>-4.0560</td>
<td>-3.4566</td>
<td>-3.1539</td>
</tr>
</tbody>
</table>

*MacKinnon critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(LOGNER,2)
Method: Least Squares
Date: 12/11/02   Time: 20:28
Sample(adjusted): 1976:1 1999:4
Included observations: 96 after adjusting endpoints

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>D(LOGNER(-1))</td>
<td>-0.845012</td>
<td>0.177604</td>
<td>-4.757838</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(LOGNER(-1),2)</td>
<td>-0.075456</td>
<td>0.140249</td>
<td>-0.538011</td>
<td>0.5919</td>
</tr>
<tr>
<td>D(LOGNER(-2),2)</td>
<td>-0.214651</td>
<td>0.102248</td>
<td>-2.099323</td>
<td>0.0386</td>
</tr>
<tr>
<td>C</td>
<td>0.058052</td>
<td>0.022617</td>
<td>2.566744</td>
<td>0.0119</td>
</tr>
<tr>
<td>@TREND(1975:1)</td>
<td>0.000675</td>
<td>0.000374</td>
<td>1.803991</td>
<td>0.0745</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.509578</td>
<td>Mean dependent var</td>
<td>0.015355</td>
<td></td>
</tr>
<tr>
<td>Adjusted R-squared</td>
<td>0.488021</td>
<td>S.D. dependent var</td>
<td>0.128696</td>
<td></td>
</tr>
<tr>
<td>S.E. of regression</td>
<td>0.092085</td>
<td>Akaike info criterion</td>
<td>-1.881521</td>
<td></td>
</tr>
<tr>
<td>Sum squared resid</td>
<td>0.771656</td>
<td>Schwarz criterion</td>
<td>-1.747961</td>
<td></td>
</tr>
<tr>
<td>Log likelihood</td>
<td>95.31299</td>
<td>F-statistic</td>
<td>23.63861</td>
<td></td>
</tr>
<tr>
<td>Durbin-Watson stat</td>
<td>1.944519</td>
<td>Prob(F-statistic)</td>
<td>0.000000</td>
<td></td>
</tr>
</tbody>
</table>

\[\text{LOGDIFP(-1)} = -0.019643 \cdot 0.015931 - 1.232996 \cdot 0.2207\]
\[\text{D(LOGDIFP(-1))} = -0.024489 \cdot 0.102568 - 0.238760 \cdot 0.8118\]
\[\text{D(LOGDIFP(-2))} = -0.073285 \cdot 0.102457 - 0.715276 \cdot 0.238760\]
\[\text{C} = -0.122892 \cdot 0.139839 - 0.878815 \cdot 0.3818\]
\[\text{R} = 0.003268 \cdot 0.001670 - 1.956507 \cdot 0.0534\]

\[\text{R-squared} = 0.203642 \cdot 0.102126\]
\[\text{Adjusted R-squared} = 0.169018 \cdot 0.073345\]
\[\text{S.E. of regression} = 0.066860 \cdot -2.522266\]
\[\text{Sum squared resid} = 127.3299 \cdot 0.4762\]
\[\text{Schwarz criterion} = 0.411262 \cdot 0.8118\]
\[\text{Log likelihood} = 1.961354 \cdot 0.000293\]
\[\text{F-statistic} = 5.881489 \cdot 0.000293\]
\[\text{Durbin-Watson stat} = 1.961354 \cdot 0.000293\]

\[\text{Augmented Dickey-Fuller Test Equation}\]

\[\text{Dependent Variable: D(LOGNER,2)}\]
\[\text{Method: Least Squares}\]
\[\text{Date: 12/11/02   Time: 20:28}\]
\[\text{Sample(adjusted): 1976:1 1999:4}\]
\[\text{Included observations: 96 after adjusting endpoints}\]
UNIT ROOT FOR DLOGDIFP

ADF Test Statistic  -4.451439
1% Critical Value*  -4.0560
5% Critical Value    -3.4566
10% Critical Value   -3.1539

*MacKinnon critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOGDIFP,2)
Method: Least Squares
Date: 12/11/02 Time: 20:58
Sample(adjusted): 1976:1 1999:4
Included observations: 96 after adjusting endpoints

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>D(LOGDIFP(-1))</td>
<td>-0.795696</td>
<td>0.178750</td>
<td>-4.451439</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(LOGDIFP(-1),2)</td>
<td>-0.219135</td>
<td>0.141737</td>
<td>-1.546061</td>
<td>0.1256</td>
</tr>
<tr>
<td>D(LOGDIFP(-2),2)</td>
<td>-0.294761</td>
<td>0.099180</td>
<td>-2.971979</td>
<td>0.0038</td>
</tr>
<tr>
<td>C</td>
<td>0.041361</td>
<td>0.015492</td>
<td>2.669797</td>
<td>0.0090</td>
</tr>
<tr>
<td>@TREND(1975:1)</td>
<td>0.000814</td>
<td>0.000319</td>
<td>2.548391</td>
<td>0.0125</td>
</tr>
</tbody>
</table>

R-squared     0.565447
Adjusted R-squared  0.546346
S.E. of regression    0.095482
Akaike info criterion -2.599506
Schwarz criterion     -2.465946
Log likelihood      129.7763
Prob(F-statistic)   0

In both cases there is no unit root as \( t > t^* \). In this way we find out that both LOGNER and LOGDIFP exhibit I(1). On this basis we can now perform a cointegration test.

COINTEGRATION TEST

Ho: No Cointegration Exists
Ha: Cointegration Exists

We conduct a Cointegration Test on LOGNER and LOGDIFP. The test indicates that at 5% significance level we should reject the Ho of no cointegration.

Date: 12/11/02 Time: 21:00
Sample: 1975:1 1999:4
Included observations: 97
Test assumption: Linear deterministic trend in the data
Series: LOGNER LOGDIFP
Lags interval: 1 to 2

<table>
<thead>
<tr>
<th>Eigenvalue</th>
<th>Likelihood Ratio</th>
<th>5 Percent Critical Value</th>
<th>1 Percent Critical Value</th>
<th>Hypothesized No. of CE(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.141033</td>
<td>17.84870</td>
<td>15.41</td>
<td>20.04</td>
<td>None *</td>
</tr>
</tbody>
</table>
Unnormalized Cointegrating Coefficients:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOGNER</td>
<td>0.017580</td>
<td>0.024214</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LOGDIFP</td>
<td>0.469132</td>
<td>0.495067</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Normalized Cointegrating Coefficients: 1 Cointegrating Equation(s)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOGNER</td>
<td>1.000000</td>
<td>1.377401</td>
<td>-2.456244</td>
<td>(16.2671)</td>
</tr>
</tbody>
</table>

Log likelihood   234.9569

Our conclusion is that there is cointegration between the two variables. We should expect that the variables be related.

ERROR CORRECTION MODEL

We reformulate the model using DLOGNER and DLOGDIFP. We obtain the ECM equation:

\[
DLOGNER = \beta_0 + \beta_1 DLOGDIFP + \beta_2 SRADJPPP + Ut
\]
We check the significance of $\beta_2$ and it is not significant at the 10% significance level. Next we check for SC of the order AR(4).

Ho: $\rho_1=\rho_2=\rho_3=\rho_4=0$
Ha: at least one is non-zero

Reject Ho iff p-value of $\text{Obs*R-squared} < \alpha=0.05$. Since $0.014503<0.05$, reject Ho. Therefore, we proved the existence of SC.

Breush-Godfrey Serial Correlation LM Test:

<table>
<thead>
<tr>
<th>F-statistic</th>
<th>Probability</th>
<th>Obs*R-squared</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.298560</td>
<td>0.014229</td>
<td>12.41731</td>
<td>0.014503</td>
</tr>
</tbody>
</table>

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 12/19/02   Time: 20:27
Presample missing value lagged residuals set to zero.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>-0.189676</td>
<td>0.393703</td>
<td>-0.481776</td>
<td>0.6311</td>
</tr>
<tr>
<td>DLOGDIFP</td>
<td>0.022461</td>
<td>0.123780</td>
<td>0.181463</td>
<td>0.8564</td>
</tr>
<tr>
<td>SRADJPPP</td>
<td>-0.017537</td>
<td>0.037078</td>
<td>-0.472966</td>
<td>0.6374</td>
</tr>
<tr>
<td>RESID(-1)</td>
<td>-0.061545</td>
<td>0.113351</td>
<td>-0.542964</td>
<td>0.5885</td>
</tr>
<tr>
<td>RESID(-2)</td>
<td>-0.154273</td>
<td>0.106022</td>
<td>-1.455103</td>
<td>0.1490</td>
</tr>
<tr>
<td>RESID(-3)</td>
<td>0.227229</td>
<td>0.104301</td>
<td>2.178588</td>
<td>0.0319</td>
</tr>
<tr>
<td>RESID(-4)</td>
<td>-0.185264</td>
<td>0.106446</td>
<td>-1.740443</td>
<td>0.0851</td>
</tr>
</tbody>
</table>

R-squared 0.125427
Adjusted R-squared 0.068390
S.E. of regression 0.083165
Akaike info criterion
Schwarz criterion
Log likelihood 109.3610
Durbin-Watson stat 1.951590

We look at the p-values of the lagged residuals and note that only res(-3) is significant at 55 level of significance. So we have to respecify our model by including AR(3).

Dependent Variable: DLOGNER
Method: Least Squares
Date: 12/19/02   Time: 20:29
Sample(adjusted): 1976:1 1999:4
Included observations: 96 after adjusting endpoints
Convergence achieved after 7 iterations

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>1.234785</td>
<td>0.567339</td>
<td>2.176451</td>
<td>0.0321</td>
</tr>
<tr>
<td>DLOGDIFP</td>
<td>0.626156</td>
<td>0.133981</td>
<td>4.673481</td>
<td>0.0000</td>
</tr>
<tr>
<td>SRADJP PPP</td>
<td>0.111121</td>
<td>0.053167</td>
<td>2.090042</td>
<td>0.0394</td>
</tr>
<tr>
<td>AR(3)</td>
<td>0.334821</td>
<td>0.106381</td>
<td>3.147371</td>
<td>0.0022</td>
</tr>
</tbody>
</table>

R-squared 0.250448  Mean dependent var 0.109207
Adjusted R-squared 0.226006  S.D. dependent var 0.095898
S.E. of regression 0.084368  Akaike info criterion - 2.066487
Sum squared resid 0.654850  Schwarz criterion - 1.959639
Log likelihood 103.1914  F-statistic 10.24667
Durbin-Watson stat 1.956015  Prob(F-statistic) 0.000007

Inverted AR Roots .69 -.35+.60i -.35 -.60i

The coefficient $\beta_2$ is individually significant which shows that there is a SR adjustment towards the LR. This SR adjustment takes place at a rate of 11% per quarter, or 44% per year.
2. Interest Rate Parity

Unit Root Tests

A. Unit Root Test on LOGDIFINT

From the relevant graph it can be seen that the data on LOGDIFINT is non-stationary and has a time trend.

Unit Root Test on LOGDIFINT

Ho: \( \rho = 1 \) => Unit Root Exists
Ha: \( \rho < 1 \) => No Unit Root Exists

\[ |ADF \text{ Test-Statistic}| < |t \text{- critical}| \Rightarrow \text{we cannot reject } H_0 \text{ even at 10\% level of significance.} \]

\( \Rightarrow \text{there exists a unit root in LOGDIFINT} \)

ADF Test Statistic -1.656763
1\% Critical Value* -4.0550
5\% Critical Value -3.4561
10\% Critical Value -3.1536

*MacKinnon critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOGDIFINT)
Method: Least Squares
Date: 12/19/02 Time: 21:20
Sample(adjusted): 1975:4 1999:4
Included observations: 97 after adjusting endpoints

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOGDIFINT(-1)</td>
<td>-0.063821</td>
<td>0.038521</td>
<td>-1.656763</td>
<td>0.1010</td>
</tr>
</tbody>
</table>
B. UNIT ROOT TEST ON DLOGDIFINT

We perform a Unit Root Test on the first difference of LOGDIFINT to check whether the data has become stationary, thus having no unit root.

Ho: Unit Root Exists
Ha: No Unit Root Exists

We see test statistic is less than the critical values at 1, 5, 10% of significance

⇒ we reject H₀ of unit root in the first difference of LOGDIFINT

⇒ LOGDIFINT is of I(1)

ADF Test Statistic -5.327428
1% Critical Value* -4.0560
5% Critical Value -3.4566
10% Critical Value -3.1539

*MacKinnon critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOGDIFINT,2)
Method: Least Squares
Date: 12/19/02 Time: 21:22
Sample(adjusted): 1976:1 1999:4
Included observations: 96 after adjusting endpoints

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>D(LOGDIFINT(-1))</td>
<td>-0.923622</td>
<td>0.173371</td>
<td>-5.327428</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(LOGDIFINT(-1),2)</td>
<td>-0.004543</td>
<td>0.144653</td>
<td>-0.031404</td>
<td>0.9750</td>
</tr>
</tbody>
</table>
The results \( t > t^* \) indicate that there is no unit root, so the \( \text{LOGDIFINT} \) variable has I(1).

From the results in the PPP case we already know that \( \text{LOGNER} \) has a unit root but \( \text{DLOGNER} \) does not. Consequently, \( \text{LOGNER} \) has I(1). Basing on this, we can conduct a cointegration test on \( \text{LOGNER} \) and \( \text{LOGDIFINT} \).

**COINTEGRATION TEST**

**Ho:** No Cointegration Exists

**Ha:** Cointegration Exists

Date: 12/19/02  Time: 21:31
Sample: 1975:1 1999:4
Included observations: 97

Test assumption: Linear deterministic trend in the data

Series: \( \text{LOGNER} \) \( \text{LOGDIFINT} \)

Lags interval: 1 to 2

<table>
<thead>
<tr>
<th>Eigenvalue</th>
<th>Likelihood Ratio</th>
<th>5 Percent Critical Value</th>
<th>1 Percent Critical Value</th>
<th>Hypothesized No. of CE(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.089508</td>
<td>10.87255</td>
<td>15.41</td>
<td>20.04</td>
<td>None</td>
</tr>
<tr>
<td>0.018151</td>
<td>1.776860</td>
<td>3.76</td>
<td>6.65</td>
<td>At most 1</td>
</tr>
</tbody>
</table>

\(*(**)\) denotes rejection of the hypothesis at 5\%(1\%) significance level
L.R. rejects any cointegration at 5\% significance level

Unnormalized Cointegrating Coefficients:

<table>
<thead>
<tr>
<th>( \text{LOGNER} )</th>
<th>( \text{LOGDIFINT} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.034795</td>
<td>0.004477</td>
</tr>
</tbody>
</table>
The Cointegration Test on LOGNER and LOGDIFINT shows that at the 5% significance level the Ho cannot be rejected, so the two variables are not cointegrated and an error correction model cannot be specified.
3. Monetary Approach

Unit Root Tests

A. UNIT ROOT TEST ON LOGM1.

From the graph we see that LOGM1 is non-stationary and there is a time trend.

Ho: Unit Root Exists
Ha: No Unit Root Exists

|ADF test statistic| < |t*| => we cannot reject H0 => there is a unit root in LOGM1

ADF Test Statistic  -0.406566  1% Critical Value* -4.0550
5% Critical Value -3.4561
10% Critical Value -3.1536

*MacKinnon critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOGM1)
Method: Least Squares
Date: 12/19/02 Time: 21:41
Sample(adjusted): 1975:4 1999:4
Included observations: 97 after adjusting endpoints

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOGM1(-1)</td>
<td>-0.013029</td>
<td>0.032048</td>
<td>-0.406566</td>
<td>0.6853</td>
</tr>
<tr>
<td>D(LOGM1(-1))</td>
<td>-0.444664</td>
<td>0.101745</td>
<td>-4.370391</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(LOGM1(-2))</td>
<td>-0.318338</td>
<td>0.100013</td>
<td>-3.182977</td>
<td>0.0020</td>
</tr>
<tr>
<td>C</td>
<td>0.069664</td>
<td>0.107565</td>
<td>0.647649</td>
<td>0.5188</td>
</tr>
<tr>
<td>@TREND(1975:1)</td>
<td>0.002954</td>
<td>0.003419</td>
<td>0.863828</td>
<td>0.3899</td>
</tr>
</tbody>
</table>

R-squared 0.240838  Mean dependent var 0.109024
Adjusted R-squared 0.207830  S.D. dependent var 0.134970
S.E. of regression 0.120128  Akaike info criterion -

1.350342
Sum squared resid 1.327635 Schwarz criterion - 1.217625
Log likelihood 70.49158 F-statistic 7.296545
Durbin-Watson stat 2.351543 Prob(F-statistic) 0.000038

B. UNIT ROOT TEST ON DLOGM1.

Ho: Unit Root Exists
Ha: No Unit Root Exists

We test the first difference of LOGM1 for unit root. The results show that there is no unit root as \( t < t^* \). We conclude that LOGM1 has I(1). We already know that LOGNER has a unit root and I(1) as DLOGNER has no unit root. Now we can conduct a Cointegration Test on LOGNER and LOGM1.

ADF Test Statistic -13.70028 1% Critical Value* -4.0560
5% Critical Value -3.4566
10% Critical Value -3.1539

*MacKinnon critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LOGM1,2)
Method: Least Squares
Date: 12/19/02 Time: 21:45
Sample(adjusted): 1976:1 1999:4
Included observations: 96 after adjusting endpoints

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>D(LOGM1(-1))</td>
<td>-2.794858</td>
<td>0.204000</td>
<td>-13.70028</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(LOGM1(-1),2)</td>
<td>1.164660</td>
<td>0.151368</td>
<td>7.694218</td>
<td>0.0000</td>
</tr>
<tr>
<td>D(LOGM1(-2),2)</td>
<td>0.581982</td>
<td>0.088022</td>
<td>6.611817</td>
<td>0.0000</td>
</tr>
<tr>
<td>C</td>
<td>0.171646</td>
<td>0.024954</td>
<td>6.878474</td>
<td>0.0000</td>
</tr>
<tr>
<td>@TREND(1975:1)</td>
<td>0.002535</td>
<td>0.000406</td>
<td>6.249245</td>
<td>0.0000</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.799697</td>
<td>Mean dependent var</td>
<td>0.002425</td>
<td></td>
</tr>
<tr>
<td>Adjusted R-squared</td>
<td>0.790892</td>
<td>S.D. dependent var</td>
<td>0.216962</td>
<td></td>
</tr>
<tr>
<td>S.E. of regression</td>
<td>0.099213</td>
<td>Akaike info criterion</td>
<td>- 1.732413</td>
<td></td>
</tr>
<tr>
<td>Sum squared resid</td>
<td>0.895737</td>
<td>Schwarz criterion</td>
<td>- 1.598853</td>
<td></td>
</tr>
<tr>
<td>Log likelihood</td>
<td>88.15583</td>
<td>F-statistic</td>
<td>90.82770</td>
<td></td>
</tr>
</tbody>
</table>
Durbin-Watson stat 1.493270  Prob(F-statistic) 0.000000

COINTEGRATION TEST

Ho: No Cointegration Exists
Ha: Cointegration Exists

The test shows that Ho is rejected at the 5% significance level so there is cointegration between LOGNER and LOGM1. This shows that the two variables are related.

Date: 12/19/02  Time: 21:47
Sample: 1975:1 1999:4
Included observations: 97

Test assumption: Linear deterministic trend in the data
Series: LOGM1 LOGNER
Lags interval: 1 to 2

<table>
<thead>
<tr>
<th>Eigenvalue</th>
<th>Likelihood Ratio</th>
<th>5 Percent Critical Value</th>
<th>1 Percent Critical Value</th>
<th>Hypothesized No. of CE(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.159273</td>
<td>22.94895</td>
<td>15.41</td>
<td>20.04</td>
<td>None **</td>
</tr>
<tr>
<td>0.061150</td>
<td>6.120626</td>
<td>3.76</td>
<td>6.65</td>
<td>At most 1 *</td>
</tr>
</tbody>
</table>

(*(**) denotes rejection of the hypothesis at 5%(1%) significance level
L.R. test indicates 2 cointegrating equation(s) at 5% significance level

Unnormalized Cointegrating Coefficients:

<table>
<thead>
<tr>
<th>LOGM1</th>
<th>LOGNER</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.256807</td>
<td>-0.218435</td>
</tr>
<tr>
<td>-0.438327</td>
<td>0.447298</td>
</tr>
</tbody>
</table>

Normalized Cointegrating Coefficients: 1 Cointegrating Equation(s)

<table>
<thead>
<tr>
<th>LOGM1</th>
<th>LOGNER</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.000000</td>
<td>-0.850582</td>
<td>3.879939</td>
</tr>
<tr>
<td></td>
<td>(0.06764)</td>
<td></td>
</tr>
</tbody>
</table>

Log likelihood 168.6668
ERROR CORRECTION MODEL

In order to correct the model we use DLOGNER and DLOGM1 and obtain the equation:

\[ \text{LOGNER} = \beta_0 + \beta_1 \text{DLOGM1} + \beta_2 \text{SRADJM1} + U_t \]

Dependent Variable: DLOGNER
Method: Least Squares
Date: 12/19/02   Time: 21:51
Sample(adjusted): 1975:2 1999:4
Included observations: 99 after adjusting endpoints

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>0.520436</td>
<td>0.207073</td>
<td>2.513296</td>
<td>0.0136</td>
</tr>
<tr>
<td>DLOGM1</td>
<td>-0.033016</td>
<td>0.074474</td>
<td>-0.443319</td>
<td>0.6585</td>
</tr>
<tr>
<td>SRADJM1</td>
<td>0.082657</td>
<td>0.042171</td>
<td>1.960024</td>
<td>0.0529</td>
</tr>
</tbody>
</table>

R-squared 0.050263
Mean dependent var 0.106703
Adjusted R-squared 0.030477
S.D. dependent var 0.095541
Akaike info criterion -1.859646
Schwarz criterion -1.781006
Log likelihood 95.05248
F-statistic 2.540326
Durbin-Watson stat 1.671174
Prob(F-statistic) 0.084131

We run the regression and check the significance of \( \beta_2 \). At 10% level it is significant.

We test for SC. The results show that there is serial correlation because p-value of the LM test statistic obs*\( R^2 \) is smaller than 0.05.

Breusch-Godfrey Serial Correlation LM Test:

<table>
<thead>
<tr>
<th>F-statistic</th>
<th>Probability</th>
<th>Obs*R-squared</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.240137</td>
<td>0.015553</td>
<td>12.22454</td>
<td>0.015757</td>
</tr>
</tbody>
</table>

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 12/19/02   Time: 21:53
Presample missing value lagged residuals set to zero.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>0.259349</td>
<td>0.236686</td>
<td>1.095752</td>
<td>0.2760</td>
</tr>
<tr>
<td>DLOGM1</td>
<td>0.005794</td>
<td>0.072314</td>
<td>0.080127</td>
<td>0.9363</td>
</tr>
</tbody>
</table>
We check the individual significance of the residuals and note that res(-1) and res(-3) are both significant at less than 5%. We include ar(1) and ar(3) and run a new regression which shows that ar(1) is insignificant at 10% => we keep only ar(3).

Dependent Variable: DLOGNER
Method: Least Squares
Date: 12/19/02   Time: 21:59
Sample(adjusted): 1976:1 1999:4
Included observations: 96 after adjusting endpoints

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>0.582524</td>
<td>0.246778</td>
<td>2.360515</td>
<td>0.0204</td>
</tr>
<tr>
<td>DLOGM1</td>
<td>-0.056794</td>
<td>0.069246</td>
<td>-0.820173</td>
<td>0.4142</td>
</tr>
<tr>
<td>SRADJM1</td>
<td>0.093917</td>
<td>0.050271</td>
<td>1.868225</td>
<td>0.0649</td>
</tr>
<tr>
<td>AR(3)</td>
<td>0.284526</td>
<td>0.102771</td>
<td>2.768535</td>
<td>0.0068</td>
</tr>
</tbody>
</table>

R-squared 0.126738  Mean dependent var 0.109207
Adjusted R-squared 0.098262  S.D. dependent var 0.095898
S.E. of regression 0.091064  Akaike info criterion 1.913727
Sum squared resid 0.762930  Schwarz criterion 1.806879
Log likelihood 95.85890  F-statistic 4.450721
Durbin-Watson stat 1.647192  Prob(F-statistic) 0.005759

The coefficient of DLOGM1 is insignificant. However we choose to keep it in the model because of economic theory’s sake.

So our final model is:
\[ \text{LOGNER} = \beta_0 + \beta_1 \text{DLOGM1} + \beta_2 \text{SRADJM1} + \delta t + u_t \]

The coefficient of \( \text{SRADJM1} \) is significant at the ten percent level, so we conclude that there is a short run adjustment of 9.4% per quarter towards a long run equilibrium.

**FIRST SPECIFICATION OF THE MONETARY MODEL**

We run the regression:

\[ \text{LOGNER} = \alpha + \beta_1 \text{DLOGM1} + \beta_2 \text{LOGM1} + \beta_3 \text{LOGNER1} + \beta_4 D79 + \beta_5 D94 \]

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>0.712660</td>
<td>0.189602</td>
<td>3.758720</td>
<td>0.0003</td>
</tr>
<tr>
<td>DLOGM1</td>
<td>-0.183017</td>
<td>0.067612</td>
<td>-2.706873</td>
<td>0.0081</td>
</tr>
<tr>
<td>LOGM1</td>
<td>0.135420</td>
<td>0.039564</td>
<td>3.422781</td>
<td>0.0009</td>
</tr>
<tr>
<td>LOGNER1</td>
<td>0.857164</td>
<td>0.039915</td>
<td>21.47471</td>
<td>0.0000</td>
</tr>
<tr>
<td>D79</td>
<td>0.120714</td>
<td>0.033312</td>
<td>3.623720</td>
<td>0.0005</td>
</tr>
<tr>
<td>D94</td>
<td>0.089398</td>
<td>0.036923</td>
<td>2.421234</td>
<td>0.0174</td>
</tr>
</tbody>
</table>

R-squared: 0.999319, Mean dependent var: 7.243198, Adjusted R-squared: 0.999282, S.D. dependent var: 3.141953, S.E. of regression: 0.084172, Akaike info criterion: 2.053221, Schwarz criterion: 1.895941, Log likelihood: 107.6345, F-statistic: 27291.41, Prob(F-statistic): 0.000000

We check the coefficients for individual significance and whether their signs match intuition. Then, we perform an LM Test to check for SC. The results indicate the existence of serial correlation. The quarterly nature of the data implies AR(4) which is also supported by the fact that only resid(-4) is the only significant at 5%.
Breusch-Godfrey Serial Correlation LM Test:

<table>
<thead>
<tr>
<th></th>
<th>F-statistic</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observations*R-squared</td>
<td>2.533010</td>
<td>0.045760</td>
</tr>
</tbody>
</table>

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 12/19/02 Time: 22:40
Presample missing value lagged residuals set to zero.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>-0.110362</td>
<td>0.216967</td>
<td>-0.508656</td>
<td>0.6123</td>
</tr>
<tr>
<td>DLOGM1</td>
<td>0.027933</td>
<td>0.068669</td>
<td>0.406770</td>
<td>0.6852</td>
</tr>
<tr>
<td>LOGM1</td>
<td>-0.022789</td>
<td>0.045339</td>
<td>-0.502647</td>
<td>0.6165</td>
</tr>
<tr>
<td>LOGNER1</td>
<td>0.022630</td>
<td>0.045829</td>
<td>0.493797</td>
<td>0.6227</td>
</tr>
<tr>
<td>D79</td>
<td>-0.002597</td>
<td>0.033194</td>
<td>-0.078249</td>
<td>0.9378</td>
</tr>
<tr>
<td>D94</td>
<td>0.000692</td>
<td>0.035790</td>
<td>0.019323</td>
<td>0.9846</td>
</tr>
<tr>
<td>RESID(-1)</td>
<td>0.018540</td>
<td>0.112645</td>
<td>-0.164588</td>
<td>0.8696</td>
</tr>
<tr>
<td>RESID(-2)</td>
<td>-0.151800</td>
<td>0.109326</td>
<td>-1.388513</td>
<td>0.1684</td>
</tr>
<tr>
<td>RESID(-3)</td>
<td>0.154147</td>
<td>0.104386</td>
<td>1.478781</td>
<td>0.1427</td>
</tr>
<tr>
<td>RESID(-4)</td>
<td>-0.261630</td>
<td>0.104386</td>
<td>-2.506356</td>
<td>0.0140</td>
</tr>
</tbody>
</table>

R-squared       | 0.102208    | Mean dependent var | 1.75E-15 |
Adjusted R-squared | 0.011420    | S.D. dependent var  | 0.081996 |
S.E. of regression | 0.081527    | Akaike info criterion | -        |
Sum squared resid | 0.591551    | Schwarz criterion   | -        |
Log likelihood   | 112.9714    | F-statistic         | 1.125782 |
Durbin-Watson stat | 1.966792    | Prob(F-statistic)   | 0.353255 |

Next we correct for SC by adding ar(4).

Dependent Variable: LOGNER
Method: Least Squares
Date: 12/19/02 Time: 22:42
Sample(adjusted): 1976:2 1999:4
Included observations: 95 after adjusting endpoints
Convergence achieved after 6 iterations

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Std. Error</th>
<th>t-Statistic</th>
<th>Prob.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>0.700711</td>
<td>0.168732</td>
<td>4.152796</td>
<td>0.0001</td>
</tr>
<tr>
<td>DLOGM1</td>
<td>-0.191010</td>
<td>0.057925</td>
<td>-3.297556</td>
<td>0.0014</td>
</tr>
<tr>
<td>LOGM1</td>
<td>0.135313</td>
<td>0.035796</td>
<td>3.780148</td>
<td>0.0003</td>
</tr>
</tbody>
</table>
The coefficient of DLOGM1 is negative and significant at 1%. This is supported by economic theory, which states that MS and exchange rate move in opposite directions (as we increase MS the exchange rate falls and vice versa). The excessively high $R^2_{adj}$ and the graphical analysis indicate that this is most probably a spurious regression. If this is the case, a test for unit roots in the variables should be conducted, their order of integration should be determined and the appropriate differencing should be applied to correct for the non-stationarity of the time series.

**SECOND SPECIFICATION OF THE MONETARY MODEL**

We can alternatively test the equation:

$$DLOGNER = \alpha + \beta_1 DLOGM1 + \beta_2 LOGNER1 + \beta_3 D79 + \beta_4 D94 + Ut$$

We perform the steps already described in the first specification. The two models are very similar and give the same results.
IV. Conclusions

Testing the three models, we conclude that there is cointegration between the variables in the PPP and Monetary models, which indicates that these models hold in the case of the Turkish economy in the period between 1975 and 1999. The statistical tests fail to provide support for the IRP model because they indicate lack of cointegration between the interest rates of USA and Turkey and the net exchange rate. A reasonable explanation for this phenomenon is that people don’t view US and Turkish bank deposits as perfect substitutes, which may be caused by various political and macroeconomic factors.