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Time Series Analysis

Interest rate pass-through in Armenia

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Term Paper

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Abstract

A central bank's policy rate can influence lending rates in the economy, as changes in the policy rate can affect the cost of borrowing for banks and other financial institutions. When the central bank raises or lowers its policy rate, this can influence the rates that banks charge their customers for loans and other types of credit. The results suggest that there is imperfect pass-through from interbank rate to lending rate for more than one year, interbank rate has no significant impact on it and also we find that there is significant relationship between retail rates

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1 Introduction

Interest rate pass-through refers to the degree to which changes in central bank policy rates are transmitted to various interest rates in the economy. While central banks use policy rates to influence the economy, the transmission mechanism is imperfect, meaning that not all changes in policy rates are fully reflected in market interest rates.

There are several reasons why interest rate pass-through can be imperfect:

Financial system structure: The structure of the financial system can affect the degree of interest rate pass-through. For example, if banks have a large market share and are less competitive, they may not fully pass on changes in policy rates to borrowers or depositors.

Information asymmetry: Borrowers and lenders may have different levels of information about market conditions, creditworthiness, and other factors that affect interest rates. This can lead to imperfect pass-through, as lenders may not adjust their rates to reflect changes in policy rates if they perceive that borrowers are less likely to shop around for better rates.

Market segmentation: Different markets for borrowing and lending may have different characteristics and pricing structures, leading to imperfect pass-through. For example, some borrowers may have limited access to credit markets or may be subject to different regulatory requirements, which can affect their borrowing costs.

Time lag: It takes time for changes in policy rates to be fully reflected in market interest rates. This time lag can be due to factors such as the frequency of interest rate adjustments or the timing of the transmission channels.

Overall, the imperfect pass-through of interest rates is a complex phenomenon that reflects the interaction of many factors in the financial system. While central banks can influence interest rates through their policy actions, the degree of pass-through depends on the broader economic and financial context in which these actions occur.

The interest rate channel is one of the transmission mechanisms through which changes in a central bank's policy rate can affect the broader economy. When the central bank adjusts its policy rate, this can lead to changes in other interest rates in the economy, such as those on loans, mortgages, and bonds. These changes in turn can affect the behavior of households, businesses, and financial markets, with potential impacts on consumption, investment, and inflation.

The interest rate channel works in several ways. First, changes in the central bank's policy rate can affect short-term interest rates, such as the rate at which banks lend to one another overnight. This can influence the cost of borrowing for households and businesses, and can affect the demand for credit and investment. For example, when the central bank lowers its policy rate, banks may pass on these lower rates to borrowers, making borrowing cheaper and potentially boosting consumption and investment.

Second, changes in the policy rate can also affect long-term interest rates, such as those on mortgages and bonds. This can influence the cost of borrowing for longer-term investments and affect the behavior of investors in financial markets. For example, if the central bank raises its policy rate, this may lead to higher bond yields, which can attract more investment and potentially lead to a stronger currency.

Overall, the interest rate channel is an important mechanism through which changes in central bank policy can affect the broader economy. However, the extent and timing of these effects can vary depending on a range of factors, including the structure of the financial system, the behavior of market participants, and the overall economic environment.

In general, when a central bank raises its policy rate, this can lead to an increase in lending rates in the economy. This is because banks and other financial institutions must pay higher interest rates to borrow money from the central bank, and this higher cost of funding can be passed on to their customers in the form of higher lending rates. Conversely, when the central bank lowers its policy rate, this can lead to a decrease in lending rates in the economy, as banks and other financial institutions can borrow money at lower rates and pass on these savings to their customers.

However, the extent to which changes in the central bank's policy rate affect lending rates can vary depending on a range of factors, including the structure of the financial system, the behavior of market participants, and the overall economic environment. For example, if the banking system is highly competitive and interest rates are already low, a central bank's rate cut may not lead to lower borrowing costs for consumers and businesses. On the other hand, if the banking system is dominated by a few large players or interest rates are already high, a central bank's rate hike may lead to a more pronounced increase in borrowing costs.

Overall, the relationship between a central bank's policy rate and lending rates in the economy is complex and can be influenced by a range of factors. Understanding this relationship is important for central banks, as it can help them to anticipate the likely impact of changes in monetary policy on the broader economy.

2 Literature Review

There are various studies and academic papers on interest rate pass-through by different authors. Here are a few examples:

A paper by Bernanke and Gertler (1995) found that the degree of interest rate pass-through to bank lending rates can vary across countries and over time, depending on factors such as the nature of the banking system, the competitive environment, and the stance of monetary policy.

A study by Clarida et al. (2002) analyzed the degree of pass-through of policy rates to retail interest rates in the United States and other industrialized countries. They found that pass-through rates were generally incomplete and varied across types of loans and financial institutions.

A paper by De Bondt and Mojon (2012) examined the pass-through of policy rates to lending rates in the euro area. They found that the pass-through was generally incomplete, with smaller and slower adjustments for retail lending rates than for wholesale market rates.

A study by Gambacorta and Mistrulli (2004) analyzed the pass-through of policy rates to bank lending rates in Italy. They found that the degree of pass-through was higher for large banks than for small banks, suggesting that market power may play a role in interest rate pass-through. Gertler and Gilchrist (1994) studied the pass-through of monetary policy to bank lending rates in the United States. They found that pass-through rates were incomplete, with less than one-for-one adjustment of bank lending rates to changes in policy rates. They attributed this to factors such as imperfect competition in the banking sector and the presence of asymmetric information.

Carlstrom and Fuerst (1997) analyzed the pass-through of monetary policy to bank lending rates in a dynamic general equilibrium model. They found that incomplete pass-through could arise due to factors such as credit market frictions and differences in the maturity structure of assets and liabilities.

Peek and Rosengren (1997) studied the pass-through of monetary policy to commercial and industrial loan rates in the United States. They found that pass-through rates were incomplete and varied across types of loans and financial institutions. They attributed this to factors such as information asymmetry and market segmentation.

Jimenez et al. (2008) examined the pass-through of monetary policy to lending rates in the euro area. They found that pass-through rates were generally incomplete, with smaller and slower adjustments for retail lending rates than for wholesale market rates. They attributed this to factors such as market power, the use of reference rates, and heterogeneity in bank lending behavior.

Overall, the literature suggests that interest rate pass-through is complex and can vary depending on a variety of factors, including the structure of the banking system, the regulatory environment, the competitive landscape, and the broader economic context.

Figure 1: Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
A	268	18855.72	2359.17	14792	22919
interbank	266	8.061015	4.427477	2.8	27.9
uptoone_dom	268	17.16704	4.021905	10.41164	33.54569
uptoone_for	268	13.4525	5.804745	6.569844	33.61
fifteend_dom	268	15.68541	5.244078	4.640236	42.93502
fifteend_for	268	12.40973	5.592462	1.842201	34.93796
month_dom	268	17.90699	3.720594	9.846412	34.01209
month_for	268	14.5461	5.669405	5.359101	39.29391
twomonth_dom	268	15.85726	5.525131	8.771974	44.58399
twomonth_for	268	13.19718	6.47289	3.730284	41.49239
threem_dom	268	17.8407	5.696154	4.116899	39.88717
threem_for	268	14.38407	7.584148	3.416978	39.4513
sixm_dom	268	18.55101	4.759936	9.560068	36.03216
sixm_for	268	13.96821	6.164768	5.784531	33.71715
year_dom	268	17.34238	3.691295	10.22849	32.39734
year_for	268	13.56049	5.385699	6.629199	32.66729
plus_dom	268	16.92699	2.739887	11.64192	24.88569
plus_for	268	13.59351	3.992168	7.84053	23.68257
date	268	619.5	77.50914	486	753
ehat	266	1.59e-10	2.602021	-4.946802	6.847766

3 Data

We have monthly data of lending interest rates for different time period. In the table we can see the coefficients and its explanation. The series begin in July of 2000 and go through October 2022, for a total of 268 observations. The following graph depicts our data.

Variable	Definition	Source
*uptoone*dom	Lending interest rates for domestic currency for up to one year	CBA Statistics
interbankrate	Interbank rate	CBA Statistics
$year_{d}om$	Lending interest rates for domestic currency for 180days to one year	CBA Statistics
$plus_{d}om$	Lending interest rates for domestic currency for more than one year	CBA Statistics

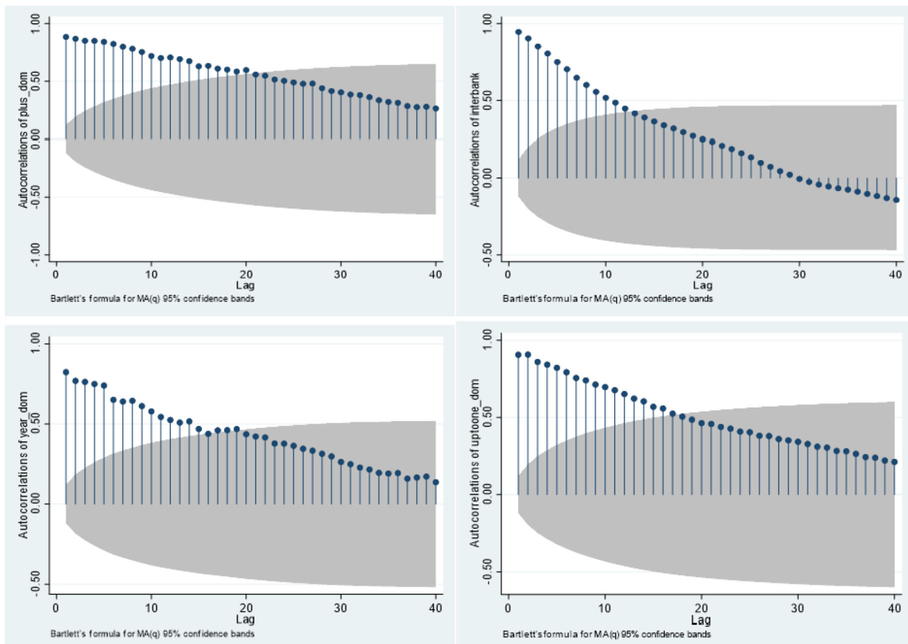
Table 1: Variables and definitions

In Table 1 we have names and definitions for our regression analysis.

In Figure 1 we can see summary statistics of the data. As we see we have 268 observations.

In Figure 2 we can see correlograms of our variables. A correlogram, also known as Auto Correlation Function (ACF) plot, is a graphic way to demonstrate serial correlation in data that doesn't remain constant with time. A correlogram gives

Figure 2: Correlograms



a fair idea of auto-correlation between data pairs at different time periods. It's used as a tool to check randomness in a data set which is done by computing auto-correlations for data values at different time lags.

The auto-correlations are near zero for any time lag separation if it is random but if not, one or more of the auto-correlations will be non-zero.

From the graph we can see that there is serial correlation in our data.

4 Methodology

In our analysis we use VECM model to estimate interest rate pass through. As we know a vector error correction model (VECM) is a statistical model used to analyze the relationship between multiple time series variables, particularly those that exhibit long-term co-movements or cointegration. VECM is a type of vector autoregression (VAR) model that is based on the concept of error correction. The basic idea is that deviations from the long-run equilibrium relationship between the variables are corrected over time through a process of gradual adjustment. The methodology for estimating a VECM involves several steps:

Data collection: The first step is to collect data on the variables of interest. These variables should be stationary or made stationary through differencing.

Model specification: The second step is to specify the appropriate lag order for the model and determine whether the variables are cointegrated. This can be done using statistical tests such as the Johansen test or the Engle-Granger test.

Estimation: The third step is to estimate the parameters of the VECM using maximum likelihood or other estimation methods.

Model evaluation: The fourth step is to evaluate the goodness of fit of the model and check for any model misspecification or violation of assumptions.

The general formula for a VECM with p lags can be expressed as:

$$\Delta y_t = \alpha + +\Pi y_{t-1} + \Gamma_1 \Delta y_{t-1} + \Gamma_2 \Delta y_{t-2} + ... + \Gamma_p \Delta y_{t-p} + \epsilon_t \tag{4.0.1}$$

where:

$\Delta \mathrm{y}_t$ is a K-dimensional vector of differenced variables.

α is a K-dimensional vector of constants.

$y_{t-1}$is a K-dimensional vector of lagged levels of the variables.

Π is a KxK matrix of coefficients that captures the long-run equilibrium relationships between the variables.

$\Gamma_1, \Gamma_2, ..., \Gamma_p$ are KxK matrices of coefficients that capture the short-run dynamics of the variables.

ϵ_t is a K-dimensional vector of error terms.

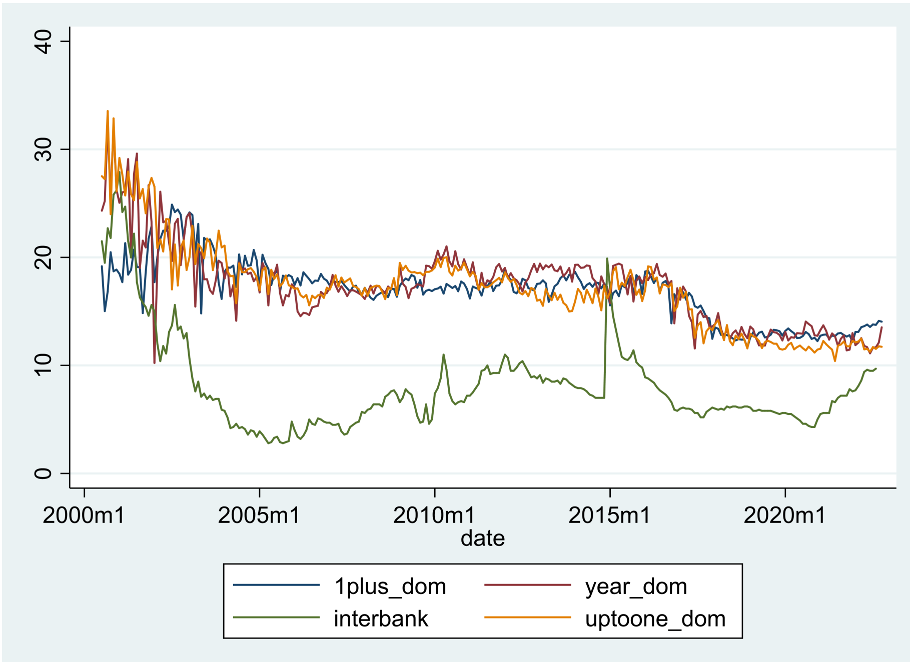
The error correction term in the VECM is captured by the coefficient matrix Π. This term reflects the adjustment process that occurs in response to deviations from the long-run equilibrium relationship between the variables. The VECM specification includes lagged differences of the variables ($\Delta y_{t-1}, \Delta y_{t-2}, ...,$ Δy_{t-p}) to capture the short-run dynamics of the system.

Fitting a VECM

vec estimates the parameters of cointegrating VECMs. There are four types of parameters of interest:

1. The parameters in the cointegrating equations β
2. The adjustment coefficients α
3. The short-run coefficients
4. Some standard functions of β and α that have useful interpretations.

Figure 3: Used data, 2000M7-2022M10



To begin our analysis firs of all we need to check stationarity of our series. We have all I(1) variables in this model. The plots on the graph also indicate that all the series are potential I(1) processes. We though that there may also be a link between the retail rates and we have lending rate up to one year and lending rate for a year as a explanatory variables.

Selecting the number of lags

To test for cointegration or fit cointegrating VECMs, we must specify how many lags to include. The order of the corresponding VECM is always one less than the VAR. The optimal number of lags in a VECM is determined using the same criteria as in a VAR model, such as the Akaike Information Criterion (AIC) or the Bayesian Information Criterion (BIC). One reason why a VECM may have fewer optimal lags than a VAR model is that the inclusion of the error correction term can help to capture some of the long-run relationships between the variables. This means that the VECM may be able to capture the same amount of information as a VAR model with fewer lags.

In addition, the error correction term in a VECM helps to reduce the impact of spurious correlations that may arise in a VAR model due to the presence of non-stationary variables. By including the error correction term, the VECM ensures that the long-run relationships between the variables are properly accounted for, which can help to improve the accuracy of the model and reduce

Figure 4: Finding optimal lag

```
. varsoc plus_dom interbank uptoone_dom year_dom
```

Selection-order criteria
Sample: 2000m11 - 2022m8 Number of obs = 262

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-2428.03				1357.75	18.5651	18.587	18.6196
1	-1741.01	1374	16	0.000	8.09567	13.4428	13.5523	13.7152
2	-1640.41	201.19	16	0.000	4.2446	12.797	12.9941	13.2874*
3	-1601.82	77.188	16	0.000	3.57295	12.6246	12.9092	13.3328
4	-1569.41	64.815*	16	0.000	3.15361*	12.4993*	12.8716*	13.4255

Endogenous: plus_dom interbank uptoone_dom year_dom
Exogenous: _cons

Figure 5: Johansen Cointegration Test 1

```
. vecrank plus_dom interbank uptoone_dom year_dom, trend(trend) lags(4)
```

Johansen tests for cointegration
Trend: trend Number of obs = 262
Sample: 2000m11 - 2022m8 Lags = 4

maximum rank	parms	LL	eigenvalue	trace statistic	5% critical value
0	56	-1602.0316	.	78.1408	54.64
1	63	-1585.1666	0.12080	44.4107	34.55
2	68	-1573.9973	0.08173	22.0723	18.17
3	71	-1566.0988	0.05851	6.2752	3.74
4	72	-1562.9612	0.02367		

the number of lags required.

So the order of the corresponding VECM is always one less than the VAR. VEC makes this adjustment automatically, so we will always refer to the order of the underlying VAR. As can be seen from the graph retail rates seem to have downwards trend we will choose an option trend for finding the cointegrating relationship. We find optimal lag which is equal to 4.

Testing for cointegration: Cointegration refers to the long-term relationship between two or more non-stationary time series variables. In econometrics, cointegration is important because it implies that the variables are not independent, but rather that they share a common stochastic trend.

The tests for cointegration are based on Johansen's method. If the log likelihood of the unconstrained model that includes the cointegrating equations is significantly different from the log likelihood of the constrained model that does not include the cointegrating equations, we reject the null hypothesis of no coin-

Estimates for deposit and lending rates and lending rates are in Appenidix.

Figure 6: Johansen Cointegration Test 2

```
. vecrank plus_dom interbank uptoone_dom year_dom, trend(trend) lags(8)

                    Johansen tests for cointegration
Trend: trend                                        Number of obs =     258
Sample:  2001m3 - 2022m8                                     Lags =       8
```

maximum rank	parms	LL	eigenvalue	trace statistic	5% critical value
0	120	-1478.7447	.	82.8707	54.64
1	127	-1460.9788	0.12866	47.3387	34.55
2	132	-1445.8405	0.11073	17.0622*	18.17
3	135	-1440.0671	0.04377	5.5155	3.74
4	136	-1437.3094	0.02115		

tegration. The body of the table presents test statistics and their critical values of the null hypotheses of no cointegration (line 1) and one or fewer cointegrating equations (line 2). The eigenvalue shown on the last line is used to compute the trace statistic in the line above it. Johansen's testing procedure starts with the test for zero cointegrating equations (a maximum rank of zero) and then accepts the first null hypothesis that is not rejected. There are results of cointegration test for 4 lag in figure 5.

But for removing serial correlation we did the same test for 8 and more lags, and we find that there is cointegration. In the output above, we strongly reject the null hypothesis of no cointegration and fail to reject the null hypothesis of at most two cointegrating equation. Thus we accept the null hypothesis that there is two cointegrating equation in the model(Figure 6).

5 Empirical findings

The interpretation of the results of a VECM model depends on the specific output generated by the model. Here we have forms of error correction term and VECM equation for lending rate for more than one year.

Here we have results of our VEC model(Figure 7). The sign of results are reverse in the long-run. In the long-run interbank rate has a negative impact on lending rate for more than one year, lending rate up to one year has no impact and lending rate for a year has a positive impact.

Coefficient estimates: These represent the relationship between the variables in the model. Positive coefficients indicate a positive relationship, while negative coefficients indicate an inverse relationship. The magnitude of the coefficient indicates the strength of the relationship. We find that only the second lag of interbank rate and lending rate for up to one year is statistically significant at 10 percent significance level, which means that change in interbank rate has a lagged and positive effect on change in lending rate for more than 1 year period(Figure 8). So, if interbank rate changes by 1 unit in January, lending rate for more than 1 year period will increase by 11 percent in March. Up to one year lending rate is significant up to 3-rd lag and has negative impact on more than 1 year lending rate and lending rate for a year has a significant impact with its 4-th lag on more than 1 year lending rate. But in this case trend coefficient is not significant.

Error correction term: This term represents the speed at which the variables in the model adjust to long-term equilibrium after a shock or disturbance. If the error correction term is negative and statistically significant, it indicates that there is a long-term relationship between the variables in the model. In our model error term is also negative and significant.

The adjustment term is statistically significant at the 1 percent level, suggesting that previous year's error or deviation from long-run equilibrium are corrected within the current year at a convergence speed of 15 percent(Figure 8).

After all we check for autocorrelation, check for normally distributed disturbances and apply other diagnostic tests.
In figure 9 we can see Lagrange-multiplier test for residuals. Results show us that there is autocorrelation only in the 3-th, 5-th and 8-th lag.

6 Conclusion

Imperfect interest rate pass-through refers to a situation in which changes in the policy interest rate set by the central bank are not fully transmitted to the lending and deposit rates offered by commercial banks to their customers. In other words, changes in the policy interest rate do not lead to a proportionate change in lending and deposit rates.

VECM model is used to study the relationship between the policy interest rate and lending rates for different time period, and the results suggest that there is imperfect pass-through from interbank rate to lending rate for more than one year but interbank rate is not significant in our model and also we find that there is significant relationship between retail rates, then we can draw several conclusions:

Monetary policy transmission is incomplete: Imperfect pass-through indicates that the central bank's monetary policy decisions have a weaker impact on the lending and deposit rates set by commercial banks. This means that the effectiveness of monetary policy in achieving its objectives, such as controlling inflation or promoting economic growth, may be limited.

The degree of pass-through may vary: The degree of interest rate pass-through may vary depending on factors such as the competitive environment in the banking sector, the level of market concentration, and the regulatory environment. This suggests that policy interventions aimed at improving pass-through may need to take into account these factors.

The impact on the economy may be ambiguous: The incomplete transmission of monetary policy may have different effects on different sectors of the economy. For example, if lending rates do not respond fully to changes in the policy interest rate, this may limit the ability of firms to invest and expand.

7 Appendix

Figure 7: Long-run equations

Cointegrating equations

Equation	Parms	chi2	P>chi2
_ce1	2	25.63168	0.0000
_ce2	2	35.61581	0.0000

Identification: beta is exactly identified

Johansen normalization restrictions imposed

beta	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
_ce1						
plus_dom	1	.	.	.	.	.
interbank	0	(omitted)				
uptoone_dom	-8.217902	1.664715	-4.94	0.000	-11.48068	-4.955121
year_dom	5.253318	1.447889	3.63	0.000	2.415507	8.09113
_trend	-.1058292	.	.	.	.	.
_cons	44.02723	.	.	.	.	.
_ce2						
plus_dom	2.22e-16	.	.	.	.	.
interbank	1	.	.	.	.	.
uptoone_dom	-9.233789	1.583095	-5.83	0.000	-12.3366	-6.13098
year_dom	5.949118	1.3769	4.32	0.000	3.250442	8.647793
_trend	-.1593076	.	.	.	.	.
_cons	66.25479	.	.	.	.	.

Figure 8: Short-run equations

```
. vec plus_dom interbank uptoone_dom year_dom,  trend(trend) lags(8) rank(2)

Vector error-correction model

Sample:  2001m3 - 2022m8                        Number of obs     =        258
                                                AIC               =   12.23132
Log likelihood =  -1445.84                      HQIC              =   12.96226
Det(Sigma_ml)  =  .8663705                      SBIC              =   14.04911

Equation           Parms      RMSE     R-sq      chi2     P>chi2
----------------------------------------------------------------
D_plus_dom           32     1.01024   0.4400   176.7723   0.0000
D_interbank          32     1.08506   0.1947   54.39958   0.0080
D_uptoone_dom        32     .947329   0.5033   228.0171   0.0000
D_year_dom           32     1.37642   0.5869   319.6558   0.0000
----------------------------------------------------------------

------------------------------------------------------------------------------
             |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
D_plus_dom   |
        _ce1 |
         L1. |  -.0542788   .0227118    -2.39   0.017    -.0987932   -.0097645
             |
        _ce2 |
         L1. |   .0401446   .0235589     1.70   0.088      -.00603    .0863193
             |
    plus_dom |
         LD. |  -.5577744    .067634    -8.25   0.000    -.6903346   -.4252141
        L2D. |  -.3545207   .0779239    -4.55   0.000    -.5072488   -.2017926
        L3D. |  -.3379194   .0819734    -4.12   0.000    -.4985842   -.1772545
        L4D. |  -.2264313   .0827811    -2.74   0.006    -.3886794   -.0641833
        L5D. |  -.0924266   .0842823    -1.10   0.273    -.2576168    .0727636
        L6D. |   .0786264   .0831869     0.95   0.345    -.0844169    .2416697
        L7D. |   .1039498   .0672774     1.55   0.122    -.0279115     .235811
```

interbank						
LD.	-.0635554	.060107	-1.06	0.290	-.1813629	.0542522
L2D.	.1140421	.0604394	1.89	0.059	-.004417	.2325013
L3D.	-.0075738	.0598841	-0.13	0.899	-.1249444	.1097968
L4D.	-.0206919	.0583803	-0.35	0.723	-.1351151	.0937313
L5D.	-.0133381	.0596922	-0.22	0.823	-.1303326	.1036565
L6D.	.0632346	.0594995	1.06	0.288	-.0533823	.1798514
L7D.	-.0220635	.0591198	-0.37	0.709	-.1379362	.0938093
uptoone_dom						
LD.	-.2886161	.0901755	-3.20	0.001	-.4653569	-.1118753
L2D.	-.2041064	.0944724	-2.16	0.031	-.3892689	-.0189439
L3D.	-.216143	.0953502	-2.27	0.023	-.403026	-.02926
L4D.	-.1047299	.0942032	-1.11	0.266	-.2893647	.0799049
L5D.	-.0492756	.0863238	-0.57	0.568	-.2184671	.1199159
L6D.	-.0370889	.080846	-0.46	0.646	-.1955441	.1213663
L7D.	-.0937768	.0670002	-1.40	0.162	-.2250948	.0375411
year_dom						
LD.	.0521522	.0692588	0.75	0.451	-.0835926	.1878969
L2D.	.0950249	.0728984	1.30	0.192	-.0478533	.2379032
L3D.	.0304188	.0769069	0.40	0.692	-.1203161	.1811536
L4D.	.1877529	.0727153	2.58	0.010	.0452336	.3302722
L5D.	.1018671	.0701863	1.45	0.147	-.0356954	.2394296
L6D.	-.027002	.0587849	-0.46	0.646	-.1422183	.0882142
L7D.	-.0214144	.048381	-0.44	0.658	-.1162395	.0734106
_trend	.0009908	.0009712	1.02	0.308	-.0009128	.0028943
_cons	-.265256	.1538542	-1.72	0.085	-.5668046	.0362927

Figure 9: LM Test for Residuals

```
. veclmar, mlag(8)
```

Lagrange-multiplier test

lag	chi2	df	Prob > chi2
1	17.9825	16	0.32492
2	24.5144	16	0.07886
3	26.8411	16	0.04328
4	15.4495	16	0.49199
5	36.5070	16	0.00246
6	17.9671	16	0.32583
7	17.4088	16	0.35963
8	34.3188	16	0.00492

H0: no autocorrelation at lag order

Figure 10: Cointegrating relationship with a trend

```
. reg plus_dom interbank date

      Source |       SS           df       MS      Number of obs   =       266
-------------+----------------------------------   F(2, 263)       =    237.21
       Model |  1279.08199         2  639.540997   Prob > F        =    0.0000
    Residual |  709.058387       263  2.69603949   R-squared       =    0.6434
-------------+----------------------------------   Adj R-squared   =    0.6406
       Total |  1988.14038       265  7.50241653   Root MSE        =     1.642

------------------------------------------------------------------------------
    plus_dom |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   interbank |   .0342665   .0241202     1.42   0.157    -.0132267    .0817597
        date |  -.0278489   .0013881   -20.06   0.000    -.0305822   -.0251156
       _cons |   33.89663   .9459058    35.84   0.000     32.03412    35.75914
------------------------------------------------------------------------------

. predict ehat2, residuals
(2 missing values generated)

. dfuller ehat2, noconstant regress lag(1)

Augmented Dickey-Fuller test for unit root         Number of obs   =       264

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -5.201            -2.580            -1.950            -1.620

------------------------------------------------------------------------------
     D.ehat2 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       ehat2 |
         L1. |  -.2353508   .0452478    -5.20   0.000    -.3244465   -.1462551
         LD. |  -.3032489   .0567938    -5.34   0.000    -.4150792   -.1914185
------------------------------------------------------------------------------
```

Results for deposit rates and lending rates without additional explanatory variables.

Lending rates

1. Cointegrating relationship with a trend for more than a year lending rate.

With a trendour tau statistics is lower than critical value, we reject null hypothesis, which says that error term is random walk and conclude that there is a cointegration(Figure 10). In this case we will run ECM with kagged residuals which is shown in Figure 11.

2. Cointegrating relationship with a trend for up to one year lending rate.

Figure 11

```
. ***there is cointegration
. ***estimating ECM
. reg D.plus_dom L.ehat L.D.interbank D.interbank

      Source |       SS           df       MS      Number of obs   =       264
-------------+----------------------------------   F(3, 260)       =     21.12
       Model |  84.7054749         3  28.2351583   Prob > F        =    0.0000
    Residual |  347.550049       260  1.33673096   R-squared       =    0.1960
-------------+----------------------------------   Adj R-squared   =    0.1867
       Total |  432.255524       263  1.64355713   Root MSE        =    1.1562

------------------------------------------------------------------------------
  D.plus_dom |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        ehat |
         L1. |  -.3304521   .0435789    -7.58   0.000    -.4162646   -.2446397
             |
   interbank |
         LD. |  -.1276369   .0597713    -2.14   0.034    -.2453344   -.0099394
         D1. |   .0364443   .0601287     0.61   0.545     -.081957    .1548455
             |
       _cons |  -.0074145   .0712524    -0.10   0.917    -.1477198    .1328908
------------------------------------------------------------------------------
```

We don't reject the Null(Figure 12) , and conclude that there is no cointegration and our error term follows random walk. In this case we will estimate ARDL in first differences(Figure 13).

3. Cointegrating relationship with a trend for one year lending rate. We reject the Null of random walk residuals(Figure 14), and conclude that there is cointegration. In this case we will estimate ECM model with lagged residuals(Figure 15).

Figure 12

```
. reg uptoone_dom interbank

      Source |       SS           df       MS      Number of obs   =       266
-------------+----------------------------------   F(1, 264)       =    196.54
       Model |  1817.89627         1  1817.89627   Prob > F        =    0.0000
    Residual |  2441.88072       264  9.24954817   R-squared       =    0.4268
-------------+----------------------------------   Adj R-squared   =    0.4246
       Total |  4259.77699       265  16.0746301   Root MSE        =    3.0413

------------------------------------------------------------------------------
 uptoone_dom |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   interbank |   .5915688   .0421969    14.02   0.000     .5084835    .6746542
       _cons |   12.43913   .3879109    32.07   0.000     11.67534    13.20292
------------------------------------------------------------------------------

.
```

```
. dfuller ehat1, noconstant regress lag(1)

Augmented Dickey-Fuller test for unit root         Number of obs   =       264

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -2.361            -2.580            -1.950            -1.620

------------------------------------------------------------------------------
     D.ehat1 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       ehat1 |
         L1. |  -.0723581   .0306416    -2.36   0.019    -.1326932    -.012023
         LD. |  -.4577163   .0554358    -8.26   0.000    -.5668727    -.34856
------------------------------------------------------------------------------
```

Figure 13

```
. reg D.uptoone_dom L.D.uptoone_dom D.interbank L.D.interbank

      Source |       SS           df       MS      Number of obs   =       264
-------------+----------------------------------   F(3, 260)       =     51.84
       Model |  252.414662         3  84.1382207   Prob > F        =    0.0000
    Residual |  421.977638       260  1.62299092   R-squared       =    0.3743
-------------+----------------------------------   Adj R-squared   =    0.3671
       Total |   674.3923        263  2.56422928   Root MSE        =     1.274

------------------------------------------------------------------------------
D.           |
 uptoone_dom |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
 uptoone_dom |
         LD. |  -.5969398   .0496076   -12.03   0.000    -.6946235    -.499256
             |
   interbank |
         D1. |   .0959248   .0663932     1.44   0.150     -.034812    .2266616
         LD. |  -.0364189    .066339    -0.55   0.583    -.1670489    .0942112
             |
       _cons |  -.0933543   .0785618    -1.19   0.236    -.2480527     .061344
------------------------------------------------------------------------------

.
end of do-file
```

Figure 14

```
. reg year_dom interbank date

      Source |       SS           df       MS      Number of obs   =       266
-------------+----------------------------------   F(2, 263)       =    310.49
       Model |  2526.04753         2  1263.02376   Prob > F        =    0.0000
    Residual |  1069.85411       263  4.06788634   R-squared       =    0.7025
-------------+----------------------------------   Adj R-squared   =    0.7002
       Total |  3595.90163       265  13.5694401   Root MSE        =    2.0169

------------------------------------------------------------------------------
    year_dom |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   interbank |   .3877687   .0296279    13.09   0.000     .3294305    .4461068
        date |  -.0268204   .0017051   -15.73   0.000    -.0301777    -.023463
       _cons |   30.83893   1.161901    26.54   0.000     28.55112    33.12674
------------------------------------------------------------------------------
```

```
. dfuller ehat1, noconstant regress lag(1)

Augmented Dickey-Fuller test for unit root         Number of obs   =       264

                               ---------- Interpolated Dickey-Fuller ----------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -8.115            -2.580            -1.950            -1.620

------------------------------------------------------------------------------
     D.ehat1 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       ehat1 |
         L1. |  -.5437231   .0670053    -8.11   0.000    -.6756605   -.4117856
         LD. |  -.0644511   .0618589    -1.04   0.298     -.186255    .0573528
------------------------------------------------------------------------------
```

Figure 15

```
***there is cointegration
***estimating ECM
reg D.year_dom L.ehat1 L.D.interbank D.interbank

      Source |       SS           df       MS      Number of obs   =       264
-------------+----------------------------------   F(3, 260)       =     36.23
       Model |  359.122404         3  119.707468   Prob > F        =    0.0000
    Residual |  859.041184       260  3.30400455   R-squared       =    0.2948
-------------+----------------------------------   Adj R-squared   =    0.2867
       Total |  1218.16359       263  4.63180072   Root MSE        =    1.8177

------------------------------------------------------------------------------
  D.year_dom |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       ehat1 |
         L1. |  -.5805971   .0561897   -10.33   0.000     -.691242   -.4699523
             |
   interbank |
         LD. |  -.1339128   .0943193    -1.42   0.157    -.3196398    .0518143
         D1. |   .1713637    .094598     1.81   0.071    -.0149121    .3576396
             |
       _cons |  -.0408966   .1120233    -0.37   0.715    -.2614851    .1796919
------------------------------------------------------------------------------
```

Deposit rates

1. Cointegrating relationship with a trend for more than one year deposit rate.

As -5.005 is less than -3.7(critical value) so we reject the Null of random walk of residuals(Figure 16) and conclude that there is cointegration. In this case we will run ECM model(Figure 17).

2. Cointegrating relationship with a trend for up to one year deposit rate.

We reject the Null of random walk residuals(Figure 18), and conclude that there is cointegration. In this case we will estimate ECM model with lagged residuals(Figure 19).

3. Cointegrating relationship with a trend for more than one year deposit rate.

And here also we reject the Null of random walk residuals(Figure 20), and conclude that there is cointegration. We will estimate ECM model with lagged residuals(Figure 21).

We can conclude that in both cases(for lending rates and deposit rates) adjustment speeds are negative and significant. And in some cases interbank rate is significant, other cases not.

Figure 16

```
. * cointegration relationship with a trend
. reg plus_dom interbank date

      Source |       SS           df       MS      Number of obs   =       266
-------------+----------------------------------   F(2, 263)       =     34.42
       Model |  276.297354         2  138.148677   Prob > F        =    0.0000
    Residual |  1055.69711       263  4.01405745   R-squared       =    0.2074
-------------+----------------------------------   Adj R-squared   =    0.2014
       Total |  1331.99446       265  5.02639421   Root MSE        =    2.0035

------------------------------------------------------------------------------
    plus_dom |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   interbank |   .1027092   .0294312     3.49   0.001     .0447583      .16066
        date |   .0139832   .0016938     8.26   0.000     .0106481    .0173183
       _cons |   .5649429   1.154188     0.49   0.625    -1.707682    2.837568
------------------------------------------------------------------------------

. predict ehat, residuals
(2 missing values generated)

. dfuller ehat, noconstant regress lag(1)

Augmented Dickey-Fuller test for unit root         Number of obs   =       264

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -5.005            -2.580            -1.950            -1.620

------------------------------------------------------------------------------
      D.ehat |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        ehat |
         L1. |  -.1993423   .0398288    -5.00   0.000    -.2777676   -.1209171
         LD. |   -.237855   .0585825    -4.06   0.000    -.3532075   -.1225026
------------------------------------------------------------------------------
```

Figure 17

```
. ***there is cointegration
. ***estimating ECM
. reg D.plus_dom L.ehat L.D.interbank D.interbank

      Source |       SS           df       MS      Number of obs   =       264
-------------+----------------------------------   F(3, 260)       =     15.99
       Model |  72.1886735         3  24.0628912   Prob > F        =    0.0000
    Residual |  391.387784       260  1.50533763   R-squared       =    0.1557
-------------+----------------------------------   Adj R-squared   =    0.1460
       Total |  463.576457       263  1.76264813   Root MSE        =    1.2269

------------------------------------------------------------------------------
  D.plus_dom |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        ehat |
         L1. |  -.2494155   .0387384    -6.44   0.000    -.3256965   -.1731345
             |
   interbank |
         LD. |   .1141847   .0638517     1.79   0.075    -.0115476    .2399169
         D1. |  -.0256541   .0639301    -0.40   0.689    -.1515408    .1002326
             |
       _cons |   .0395957   .0756152     0.52   0.601    -.1093005    .1884919
------------------------------------------------------------------------------
```

Figure 18

```
. reg year_dom interbank date

      Source |       SS           df       MS      Number of obs   =       266
-------------+----------------------------------   F(2, 263)       =    267.11
       Model |  1713.72685         2  856.863425   Prob > F        =    0.0000
    Residual |  843.676035       263  3.20789367   R-squared       =    0.6701
-------------+----------------------------------   Adj R-squared   =    0.6676
       Total |  2557.40289       265  9.65057693   Root MSE        =    1.7911

------------------------------------------------------------------------------
    year_dom |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   interbank |   .6007491   .0263104    22.83   0.000     .5489433    .6525549
        date |   .0062271   .0015142     4.11   0.000     .0032457    .0092086
       _cons |   1.796372   1.031798     1.74   0.083    -.2352642    3.828009
------------------------------------------------------------------------------

. predict ehat1, residuals
(2 missing values generated)

. dfuller ehat1, noconstant regress lag(1)

Augmented Dickey-Fuller test for unit root         Number of obs   =       264

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -8.603            -2.580            -1.950            -1.620

------------------------------------------------------------------------------
     D.ehat1 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       ehat1 |
         L1. |  -.5184507   .0602637    -8.60   0.000    -.6371136   -.3997879
         LD. |   -.043331   .0590878    -0.73   0.464    -.1596783    .0730164
------------------------------------------------------------------------------
```

Figure 19

```
. reg D.year_dom L.ehat1 L(0/3).D.interbank D.interbank
note: D.interbank omitted because of collinearity

      Source |       SS           df       MS      Number of obs   =       262
-------------+----------------------------------   F(5, 256)       =     16.86
       Model |  138.078665         5  27.6157329   Prob > F        =    0.0000
    Residual |  419.271061       256  1.63777758   R-squared       =    0.2477
-------------+----------------------------------   Adj R-squared   =    0.2330
       Total |  557.349725       261  2.13543956   Root MSE        =    1.2798

------------------------------------------------------------------------------
  D.year_dom |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       ehat1 |
         L1. |  -.4415745   .0523716    -8.43   0.000    -.5447085   -.3384406
             |
   interbank |
         D1. |   .0878991   .0679771     1.29   0.197    -.0459665    .2217647
         LD. |  -.0772312    .070781    -1.09   0.276    -.2166184    .0621559
        L2D. |  -.1911043    .068753    -2.78   0.006    -.3264978   -.0557109
        L3D. |   .0525107   .0686412     0.77   0.445    -.0826626     .187684
         D1. |          0  (omitted)
             |
       _cons |  -.0431632   .0793973    -0.54   0.587    -.1995182    .1131917
------------------------------------------------------------------------------
```

Figure 20

```
. reg year_dom interbank date

      Source |       SS           df       MS      Number of obs   =       266
-------------+----------------------------------   F(2, 263)       =    267.11
       Model |  1713.72685         2  856.863425   Prob > F        =    0.0000
    Residual |  843.676035       263  3.20789367   R-squared       =    0.6701
-------------+----------------------------------   Adj R-squared   =    0.6676
       Total |  2557.40289       265  9.65057693   Root MSE        =    1.7911

------------------------------------------------------------------------------
    year_dom |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   interbank |   .6007491   .0263104    22.83   0.000     .5489433    .6525549
        date |   .0062271   .0015142     4.11   0.000     .0032457    .0092086
       _cons |   1.796372   1.031798     1.74   0.083    -.2352642    3.828009
------------------------------------------------------------------------------

. predict ehat2, residuals
(2 missing values generated)

. dfuller ehat2, noconstant regress lag(1)

Augmented Dickey-Fuller test for unit root         Number of obs   =       264

                               ---------- Interpolated Dickey-Fuller ---------
                  Test         1% Critical       5% Critical      10% Critical
               Statistic           Value             Value             Value
------------------------------------------------------------------------------
 Z(t)             -8.603            -2.580            -1.950            -1.620

------------------------------------------------------------------------------
     D.ehat2 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       ehat2 |
         L1. |  -.5184507   .0602637    -8.60   0.000    -.6371136   -.3997879
         LD. |   -.043331   .0590878    -0.73   0.464    -.1596783    .0730164
------------------------------------------------------------------------------
```

Figure 21

```
. reg D.uptoone_dom L.ehat2 L(0/5).D.interbank D.interbank
note: D.interbank omitted because of collinearity

      Source |       SS           df       MS      Number of obs   =       260
-------------+----------------------------------   F(7, 252)       =      8.44
       Model |    39.85216         7  5.69316572   Prob > F        =    0.0000
    Residual |  169.909427       252  .674243757   R-squared       =    0.1900
-------------+----------------------------------   Adj R-squared   =    0.1675
       Total |  209.761587       259  .809890297   Root MSE        =    .82112

------------------------------------------------------------------------------
D.           |
 uptoone_dom |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       ehat2 |
         L1. |  -.0420647    .034437    -1.22   0.223    -.1098857    .0257564
             |
   interbank |
         D1. |   .1063895   .0450181     2.36   0.019     .0177297    .1950492
         LD. |   .1409217   .0470569     2.99   0.003     .0482468    .2335966
        L2D. |  -.0450903   .0446869    -1.01   0.314    -.1330977    .0429172
        L3D. |   .1897254   .0453588     4.18   0.000     .1003947    .2790561
        L4D. |  -.0761926   .0431283    -1.77   0.078    -.1611305    .0087453
        L5D. |   .1466114   .0433807     3.38   0.001     .0611764    .2320463
         D1. |          0  (omitted)
             |
       _cons |  -.0010015   .0514058    -0.02   0.984    -.1022412    .1002381
------------------------------------------------------------------------------

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```