INTERNATIONAL UNIVERSITY - VNU HCMC

School of Economics, Finance, and Accounting

Time Series Econometrics

Assignment 6

VAR, SVAR, IRF, Granger Causality, Johnhansen test

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Contents

1 Question 1

i. Import the data, and limit the sample to the period of 1985-2019. Plot the three variables in a single graph

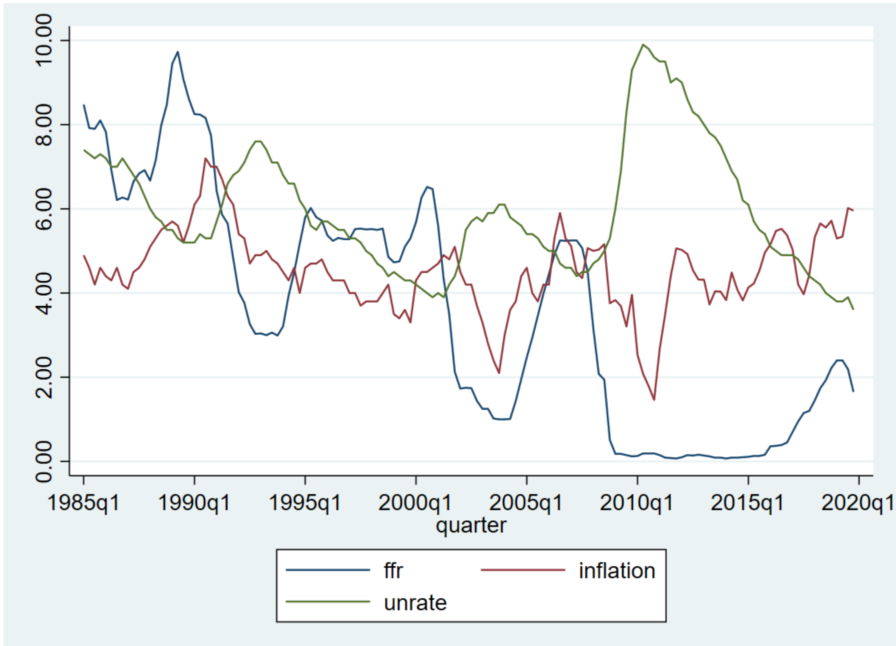

Figure 1: Plot of ffr, inflation rate, and unemployment rate

ii. Estimate the VAR model to learn about the dynamic interrelationships among the three variables. Note: use varsoc to select the optimal lag lengths.

```
. varsoc ffr inflation unrate, maxlag(10)

Lag-order selection criteria

Sample: 1987q3 thru 2019q4                          Number of obs = 130
```

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-704.391				10.6899	10.8829	10.9098	10.9491
1	-150.51	1107.8	9	0.000	.002446	2.50016	2.60771	2.76485
2	-61.6687	177.68	9	0.000	.000716	1.27183	1.46005*	1.73504*
3	-48.1882	26.961	9	0.001	.000669	1.2029	1.47178	1.86463
4	-43.2135	9.9494	9	0.355	.000712	1.26482	1.61438	2.12508
5	-20.6925	45.042	9	0.000	.00058*	1.05681*	1.48703	2.11559
6	-17.6368	6.1115	9	0.729	.000637	1.14826	1.65914	2.40556
7	-7.98226	19.309*	9	0.023	.000633	1.13819	1.72974	2.59401
8	-1.33779	13.289	9	0.150	.000659	1.17443	1.84664	2.82877
9	5.9769	14.629	9	0.102	.00068	1.20036	1.95324	3.05322
10	9.94049	7.9272	9	0.542	.000741	1.27784	2.11139	3.32923

```
* optimal lag
Endogenous: ffr inflation unrate
 Exogenous: _cons
```

Figure 2: Find optimal lag

AIC smallest at **lag 5** → The optimal lag length is 5.

$$inflation_t = \alpha_{10} + \sum_{i=1}^{5} \beta_{1i} inflation_{t-i} + \sum_{j=1}^{5} \gamma_{1j} unrate_{t-j} + \sum_{k=1}^{5} \theta_{1k} ffr_{t-k} + \epsilon_{1t}$$

$$unrate_t = \alpha_{20} + \sum_{i=1}^{5} \beta_{2i} inflation_{t-i} + \sum_{j=1}^{5} \gamma_{2j} unrate_{t-j} + \sum_{k=1}^{5} \theta_{2k} ffr_{t-k} + \epsilon_{2t}$$

$$ffr_t = \alpha_{30} + \sum_{i=1}^{5} \beta_{3i} inflation_{t-i} + \sum_{j=1}^{5} \gamma_{3j} unrate_{t-j} + \sum_{k=1}^{5} \theta_{3k} ffr_{t-k} + \epsilon_{3t}$$

White noise test for residual

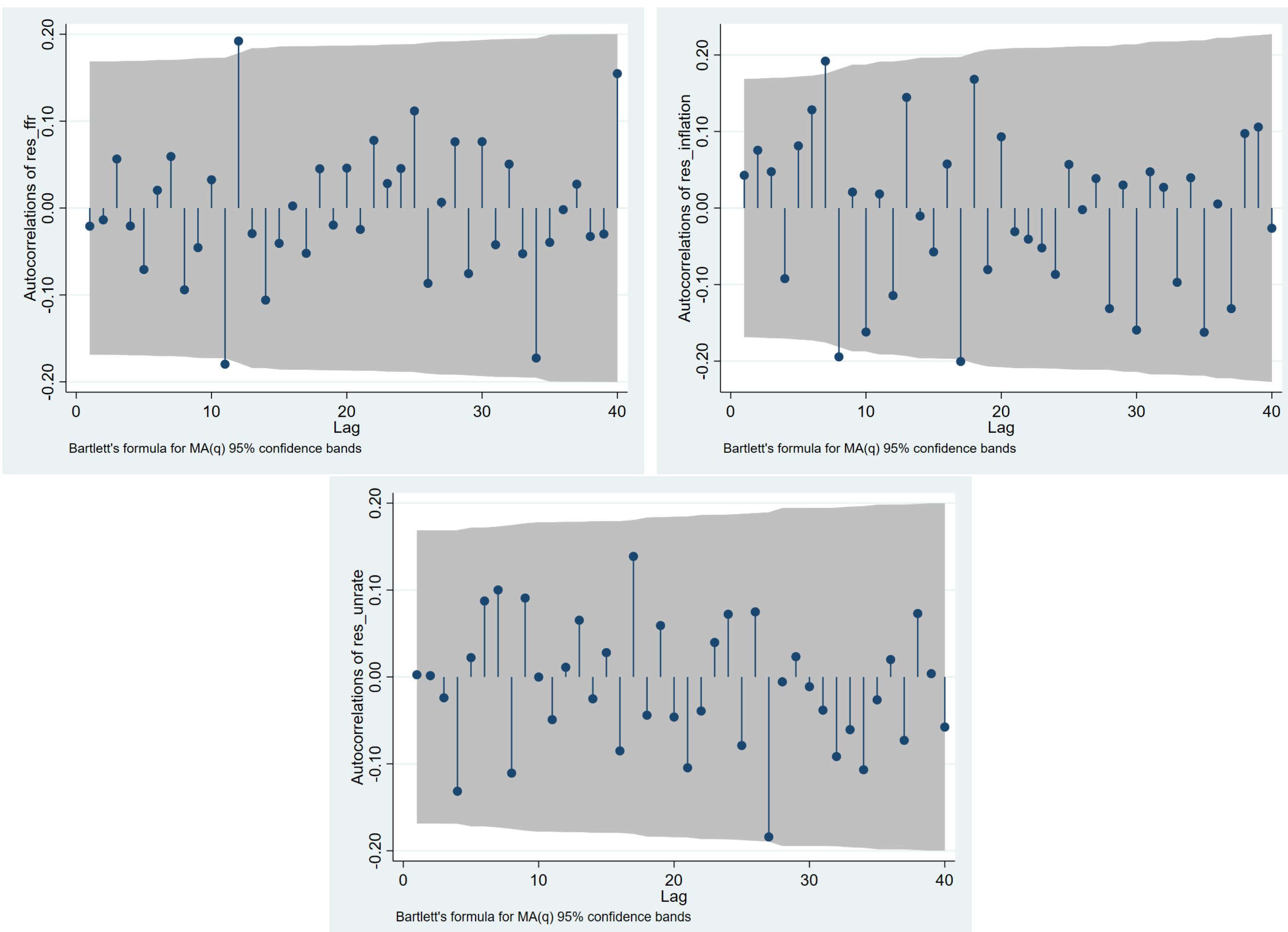

Figure 3: residual VAR(6)

These graphs indicated that ϵ_t in 3 equations of VAR(5) is white noise

```
. var ffr inflation unrate, lags(1(1)5)

Vector autoregression

Sample: 1986q2 thru 2019q4                      Number of obs     =        135
Log likelihood =  -25.91841                     AIC               =   1.095088
FPE            =    .000602                     HQIC              =   1.514864
Det(Sigma_ml)  =   .0002947                     SBIC              =   2.128074
```

Equation	Parms	RMSE	R-sq	chi2	P>chi2
ffr	16	.31811	0.9877	10817.16	0.0000
inflation	16	.356054	0.8853	1042.457	0.0000
unrate	16	.184206	0.9867	9979.839	0.0000

	Coefficient	Std. err.	z	P>|z|	[95% conf.	interval]
ffr						
ffr						
L1.	1.679996	.0853367	19.69	0.000	1.512739	1.847253
L2.	-.7985714	.1647833	-4.85	0.000	-1.121541	-.475602
L3.	.2258054	.1724223	1.31	0.190	-.112136	.5637468
L4.	-.2643124	.1617541	-1.63	0.102	-.5813446	.0527197
L5.	.1440799	.087617	1.64	0.100	-.0276464	.3158061
inflation						
L1.	-.1101891	.0666056	-1.65	0.098	-.2407337	.0203554
L2.	.0526814	.0941237	0.56	0.576	-.1317977	.2371605
L3.	.1335947	.0926093	1.44	0.149	-.047916	.3151055
L4.	-.1951648	.0931087	-2.10	0.036	-.3776545	-.0126751
L5.	.0644472	.0669407	0.96	0.336	-.0667541	.1956485
unrate						
L1.	-.1317593	.1514814	-0.87	0.384	-.4286574	.1651388
L2.	.3456416	.2625302	1.32	0.188	-.1689082	.8601913
L3.	-.6152486	.2695924	-2.28	0.022	-1.14364	-.0868572
L4.	.4955675	.2678204	1.85	0.064	-.0293509	1.020486
L5.	-.0856784	.1483135	-0.58	0.563	-.3763674	.2050106
_cons	.2135515	.2228033	0.96	0.338	-.223135	.650238
inflation						
ffr						
L1.	.029825	.0955156	0.31	0.755	-.1573822	.2170322
L2.	-.0417233	.1844386	-0.23	0.821	-.4032162	.3197697
L3.	.1372436	.1929887	0.71	0.477	-.2410074	.5154945
L4.	-.1519946	.181048	-0.84	0.401	-.5068423	.202853
L5.	.0412914	.098068	0.42	0.674	-.1509182	.2335011
inflation						
L1.	1.003247	.0745503	13.46	0.000	.8571308	1.149362
L2.	-.0114962	.1053508	-0.11	0.913	-.2179799	.1949876
L3.	-.0255011	.1036557	-0.25	0.806	-.2286625	.1776602
L4.	-.5507862	.1042147	-5.29	0.000	-.7550432	-.3465292
L5.	.4814801	.0749253	6.43	0.000	.3346292	.628331
unrate						
L1.	.1477326	.1695501	0.87	0.384	-.1845795	.4800446
L2.	-.5606503	.2938447	-1.91	0.056	-1.136575	.0152747
L3.	.2960634	.3017493	0.98	0.327	-.2953543	.8874811
L4.	-.0850715	.299766	-0.28	0.777	-.672602	.5024591
L5.	.2071651	.1660042	1.25	0.212	-.1181972	.5325275
_cons	.3829082	.2493792	1.54	0.125	-.1058661	.8716826
unrate						
ffr						
L1.	-.094929	.0494153	-1.92	0.055	-.1917813	.0019232
L2.	-.0000652	.0954199	-0.00	0.999	-.1870847	.1869543
L3.	.0951752	.0998433	0.95	0.340	-.1005141	.2908645
L4.	-.0164602	.0936657	-0.18	0.861	-.2000417	.1671213
L5.	.014688	.0507358	0.29	0.772	-.0847522	.1141283
inflation						
L1.	-.0519973	.0385688	-1.35	0.178	-.1275907	.0235962
L2.	.0806227	.0545035	1.48	0.139	-.0262022	.1874477
L3.	-.0412556	.0536266	-0.77	0.442	-.1463617	.0638505
L4.	.0278152	.0539158	0.52	0.606	-.0778578	.1334881
L5.	-.0142897	.0387628	-0.37	0.712	-.0902635	.061684
unrate						
L1.	1.415473	.0877172	16.14	0.000	1.24355	1.587395
L2.	-.2853756	.1520214	-1.88	0.060	-.5833321	.012581
L3.	-.0573318	.1561109	-0.37	0.713	-.3633035	.2486399
L4.	-.1859625	.1550848	-1.20	0.230	-.4899232	.1179982
L5.	.0841096	.0858828	0.98	0.327	-.0842175	.2524368
_cons	.1545345	.1290171	1.20	0.231	-.0983344	.4074034

Figure 4: VAR(6)

The estimated result shows:

- lag 1, 2 of ffr, lag 4 of inflation, and lag 3 of urate affect ffr
- lag 1, 4, 5 of inflation affect inflation
- lag 1 of unrate affect unrate

iii. Perform the impulse response function (IRF) analysis and make a brief comments (4-6 lines) on it.

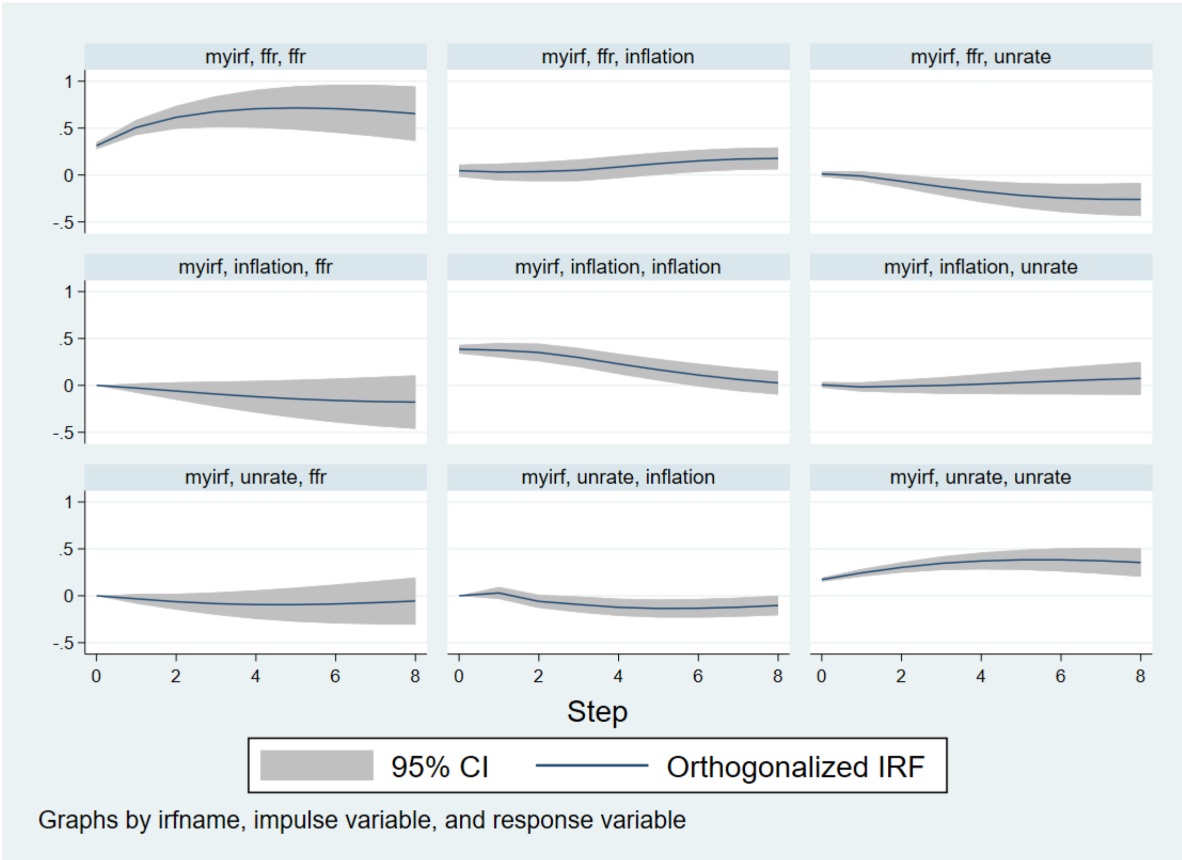

Figure 5: Impulse Respond Function

Response of Fed Fund Rate

- **To Own Shock (ffr)** The Federal Funds Rate response positively to its own lags
- **To Inflation Shock** The policy response is delayed. There is no effect in the early periods. however, the rate gradually have amoderate positive effect in the long run
- **To Unemployment Shock (unrate)** The rate shows no change in short-run but moderate negative response in the long run.

Response of Inflation rate

- **To Own Shock (inflation)** The response is positive during the early periods and then statistically insignificant after the 5th period.
- **To FFR Shock** The response of inflation to a monetary policy shock is not statistically significant.
- **To Unemployment Shock** The response of inflation to unemployment rate shock is not statistically significant.

Response of Unemployment Rate

- **To Own Shock (unrate)** The unemployment rate responds positively to its own shock.

- **To FFR Shock** There is no statistically significant response of unemployment to the shock of the Federal Funds Rate.

-

- **To Inflation Shock** The response of unemployment to inflation shocks is approximately zero.

iv. Perform the Granger causality test based on your VAR estimation and interpret the results.

Granger causality Wald tests

Equation	Excluded	chi2	df	Prob > chi2
ffr	inflation	8.2442	5	0.143
ffr	unrate	8.7393	5	0.120
ffr	ALL	14.854	10	0.137
inflation	ffr	2.8665	5	0.721
inflation	unrate	18.951	5	0.002
inflation	ALL	30.064	10	0.001
unrate	ffr	19.752	5	0.001
unrate	inflation	2.8328	5	0.726
unrate	ALL	24.666	10	0.006

Figure 6: Granger Causality test

Interpretation

- We can reject the null hypothesis that unrate does not Granger-cause inflation ($p-value = 0.002$) $\rightarrow$ unrate Granger-cause inflation

- We can reject the null hypothesis that ffr does not Granger-cause unrate ($p-value = 0.001$) $\rightarrow$ ffr Granger-cause unrate

2 Question 2

i. Import data as the daily interval and use the following code to get the time interval as weekly: `tsset your_time_var, delta(7)`
Convert both price series to a common unit (USD/kg). Plot the two price series on the same chart using two different y-axes.

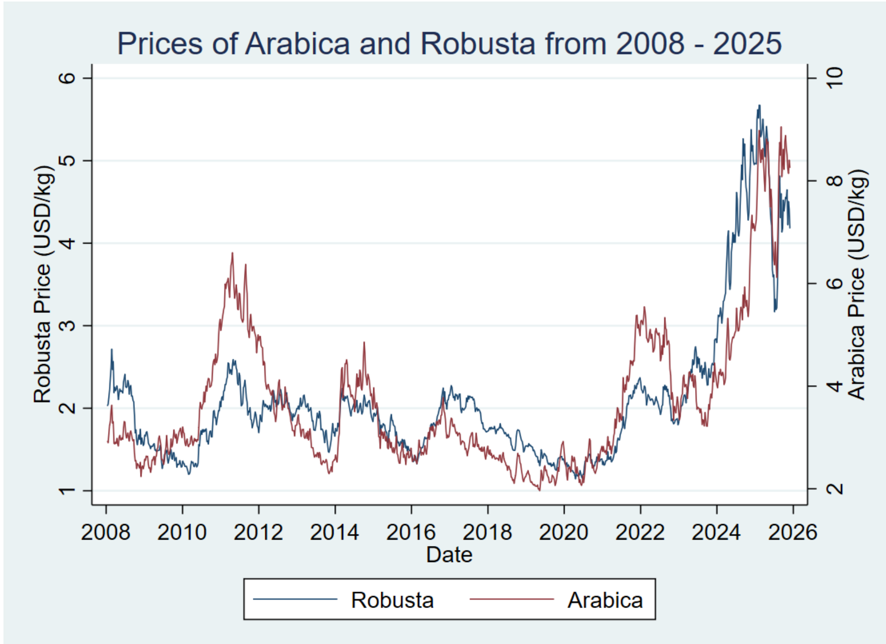

Figure 7: Arabica and Robusta weekly

ii. Use the full sample and perform the ADF tests to determine whether these variables are integrated of order 1. Hint: Use varsoc d.your_var, maxlag(12) to select an appropriate lag length for the ADF tests.

Lag-order selection criteria

Sample: 4/6/2008 thru 11/30/2025 Number of obs = 922

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-1654.07				2.12187	3.59018	3.59217	3.59541
1	280.687	3869.5	1	0.000	.031988	-.604527	-.600532	-.594057
2	285.152	8.9301	1	0.003	.031748	-.612043	-.606051	-.596339
3	285.173	.0421	1	0.837	.031816	-.60992	-.60193	-.58898
4	287.683	5.0191	1	0.025	.031712	-.613194	-.603207	-.58702
5	295.412	15.459	1	0.000	.031252	-.627792	-.615807*	-.596383*
6	295.949	1.0738	1	0.300	.031284	-.626787	-.612805	-.590143
7	296.715	1.5323	1	0.216	.031299	-.62628	-.610301	-.584401
8	297.667	1.9047	1	0.168	.031303	-.626177	-.6082	-.579063
9	298.114	.89318	1	0.345	.03134	-.624976	-.605002	-.572628
10	298.207	.18678	1	0.666	.031402	-.62301	-.601038	-.565426
11	299.07	1.7244	1	0.189	.031411	-.622711	-.598741	-.559892
12	303.437	8.7341*	1	0.003	.031183*	-.630014*	-.604048	-.561961

* optimal lag
Endogenous: A_kg
Exogenous: _cons

Lag-order selection criteria

Sample: 4/13/2008 thru 11/30/2025 Number of obs = 921

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	279.72				.031964	-.605255	-.603256	-.600016
1	283.943	8.4455	1	0.004	.031741	-.612253	-.608255	-.601775
2	283.948	.01163	1	0.914	.03181	-.610094	-.604097	-.594376
3	286.704	5.5115	1	0.019	.031689	-.613907	-.60591	-.59295
4	294.614	15.819	1	0.000	.031217	-.628911	-.618915*	-.602714*
5	295.097	.9665	1	0.326	.031252	-.627789	-.615794	-.596353
6	295.805	1.4162	1	0.234	.031272	-.627155	-.61316	-.59048
7	296.815	2.0201	1	0.155	.031271	-.627177	-.611183	-.585262
8	297.223	.81643	1	0.366	.031312	-.625892	-.607899	-.578738
9	297.336	.22569	1	0.635	.031372	-.623965	-.603973	-.571572
10	298.14	1.6079	1	0.205	.031385	-.62354	-.601548	-.565907
11	302.281	8.2824*	1	0.004	.031172*	-.630361*	-.60637	-.567489
12	302.534	.50621	1	0.477	.031223	-.628739	-.602749	-.560627

* optimal lag
Endogenous: D.A_kg
Exogenous: _cons

Figure 8: Varsoc A and d.A

- For Arabica, AIC smallest at **lag 12** → The optimal lag length is 12.
- For difference of Arabica, AIC smallest at **lag 11** → The optimal lag length is 11.

Lag-order selection criteria

Sample: **4/6/2008** thru **11/30/2025** Number of obs = **922**

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-1206.15				.80305	2.61854	2.62054	2.62377
1	826.717	4065.7	1	0.000	.009786	-1.78897	-1.78498	-1.7785*
2	828.256	3.0775	1	0.079	.009774	-1.79014	-1.78415	-1.77444
3	829.298	2.0837	1	0.149	.009773	-1.79023	-1.78224	-1.76929
4	830.537	2.4782	1	0.115	.009768	-1.79075	-1.78076	-1.76458
5	835.751	10.429	1	0.001	.009679	-1.79989	-1.78791	-1.76849
6	835.947	.39203	1	0.531	.009696	-1.79815	-1.78417	-1.76151
7	836.166	.4374	1	0.508	.009713	-1.79646	-1.78048	-1.75458
8	838.593	4.8536	1	0.028	.009683	-1.79955	-1.78157	-1.75244
9	840.722	4.2575	1	0.039	.009659	-1.802	-1.78202	-1.74965
10	844.271	7.0979	1	0.008	.009606	-1.80753	-1.78556	-1.74994
11	844.826	1.1101	1	0.292	.009615	-1.80656	-1.78259	-1.74374
12	852.476	15.302*	1	0.000	.009477*	-1.82099*	-1.79502*	-1.75294

* optimal lag
Endogenous: **R_kg**
Exogenous: **_cons**

Lag-order selection criteria

Sample: **4/13/2008** thru **11/30/2025** Number of obs = **921**

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	824.957				.009783	-1.78927	-1.78727	-1.78403*
1	826.354	2.7945	1	0.095	.009774	-1.79013	-1.78613	-1.77965
2	827.246	1.7847	1	0.182	.009777	-1.78989	-1.7839	-1.77418
3	828.616	2.7391	1	0.098	.009769	-1.7907	-1.7827	-1.76974
4	834.1	10.968	1	0.001	.009674	-1.80043	-1.79044	-1.77424
5	834.262	.32355	1	0.569	.009692	-1.79861	-1.78662	-1.76718
6	834.429	.33516	1	0.563	.009709	-1.79681	-1.78281	-1.76013
7	837.01	5.1622	1	0.023	.009676	-1.80024	-1.78425	-1.75832
8	838.996	3.9716	1	0.046	.009655	-1.80238	-1.78439	-1.75523
9	842.723	7.4544	1	0.006	.009598	-1.8083	-1.78831	-1.75591
10	843.224	1.0018	1	0.317	.009609	-1.80722	-1.78523	-1.74959
11	850.588	14.726*	1	0.000	.009477*	-1.82104*	-1.79705*	-1.75816
12	851.427	1.6782	1	0.195	.00948	-1.82069	-1.7947	-1.75258

* optimal lag
Endogenous: **D.R_kg**
Exogenous: **_cons**

Figure 9: Varsoc R and d.R

- For Robusta, AIC smallest at **lag 12** → The optimal lag length is 12.
- For difference of Robusta, AIC smallest at **lag 11** → The optimal lag length is 11.

. dfuller A_kg, lags(12)

Augmented Dickey-Fuller test for unit root

Variable: **A_kg** Number of obs = **921**
Number of lags = **12**

H0: Random walk without drift, d = 0

	Test statistic	Dickey-Fuller critical value 1%	5%	10%
Z(t)	**-0.759**	**-3.430**	**-2.860**	**-2.570**

MacKinnon approximate *p*-value for Z(t) = **0.8309**.

. dfuller d.A_kg, lags(11)

Augmented Dickey-Fuller test for unit root

Variable: **D.A_kg** Number of obs = **921**
Number of lags = **11**

H0: Random walk without drift, d = 0

	Test statistic	Dickey-Fuller critical value 1%	5%	10%
Z(t)	**-8.174**	**-3.430**	**-2.860**	**-2.570**

MacKinnon approximate *p*-value for Z(t) = **0.0000**.

Figure 10: Test order of integration of Arabica

- AFD test of Arabica with 12 lags indicates the non-stationary while we can not reject the null hypothesis of nonstationary (p-value = 0.8309)
- AFD test of difference off Arabica with 11 lags indicates the stationary while we can reject the null hypothesis of nonstationary (p-value = 0.0000)

```
. dfuller R_kg, lags(12)

Augmented Dickey-Fuller test for unit root

Variable: R_kg                              Number of obs  = 921
                                            Number of lags =  12

H0: Random walk without drift, d = 0

                                       Dickey-Fuller
                   Test      ---------- critical value ----------
              statistic           1%           5%          10%
------------------------------------------------------------------
 Z(t)            -0.834       -3.430       -2.860       -2.570
------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.8090.
```

```
. dfuller d.R_kg, lags(11)

Augmented Dickey-Fuller test for unit root

Variable: D.R_kg                            Number of obs  = 921
                                            Number of lags =  11

H0: Random walk without drift, d = 0

                                       Dickey-Fuller
                   Test      ---------- critical value ----------
              statistic           1%           5%          10%
------------------------------------------------------------------
 Z(t)            -8.535       -3.430       -2.860       -2.570
------------------------------------------------------------------
MacKinnon approximate p-value for Z(t) = 0.0000.
```

Figure 11: Test order of integration of Robusta

- AFD test of Robusta with 12 lags indicates the non-stationary while we can not reject the null hypothesis of nonstationary (p-value = 0.8309)
- AFD test of difference off Arabica with 11 lags indicates the stationary while we can reject the null hypothesis of nonstationary (p-value = 0.0000)

Conclusion: Both Arabica and Robusta are integrated of I(1)

iii. Assuming both variables are I(1), conduct a Johansen cointegration test for the two coffee price series. Do you find evidence of a cointegrating relationship? If so, estimate a Vector Error Correction Model (VECM) and briefly comment on the long-run and short-run results.

```
. varsoc A_kg R_kg, maxlag(12)

Lag-order selection criteria

   Sample: 4/6/2008 thru 11/30/2025                    Number of obs = 922
```

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-2315.17				.522383	5.0264	5.03039	5.03687
1	1337.07	7304.5	4	0.000	.000191	-2.88736	-2.87538	-2.85595*
2	1344.53	14.919	4	0.005	.00019	-2.89486	-2.87489	-2.84252
3	1356.46	23.856	4	0.000	.000186	-2.91206	-2.8841	-2.83877
4	1363.25	13.576	4	0.009	.000185	-2.91811	-2.88216	-2.82388
5	1374.2	21.899	4	0.000	.000182	-2.93318	-2.88924*	-2.81802
6	1380.9	13.406	4	0.009	.000181	-2.93905	-2.88711	-2.80294
7	1382.09	2.3731	4	0.667	.000183	-2.93294	-2.87302	-2.7759
8	1386.07	7.9672	4	0.093	.000183	-2.93291	-2.865	-2.75492
9	1389.75	7.3637	4	0.118	.000183	-2.93222	-2.85632	-2.73329
10	1393.24	6.9831	4	0.137	.000183	-2.93112	-2.84722	-2.71125
11	1394.21	1.94	4	0.747	.000184	-2.92454	-2.83266	-2.68374
12	1406.84	25.248*	4	0.000	.000181*	-2.94325*	-2.84338	-2.68151

```
   * optimal lag
   Endogenous: A_kg R_kg
    Exogenous: _cons
```

Figure 12: varsoc A and R

AIC smallest at lags 12 → the optimum lag length is 12

Long-run relationship: Johansen cointegration test

```
. vecrank A_kg R_kg, trend(rconstant) lags(12)

Johansen tests for cointegration
Trend: Restricted constant                    Number of obs  = 922
Sample: 4/6/2008 thru 11/30/2025              Number of lags =  12
```

Maximum rank	Params	LL	Eigenvalue	Trace statistic	Critical value 5%
0	44	1401.082	.	11.5126*	19.96
1	48	1405.4825	0.00950	2.7116	9.42
2	50	1406.8383	0.00294		

* selected rank

```
. vecrank A_kg R_kg, trend(rtrend) lags(12)

Johansen tests for cointegration
Trend: Restricted                             Number of obs  = 922
Sample: 4/6/2008 thru 11/30/2025              Number of lags =  12
```

Maximum rank	Params	LL	Eigenvalue	Trace statistic	Critical value 5%
0	46	1401.5029	.	15.2559*	25.32
1	50	1406.2678	0.01028	5.7261	12.25
2	52	1409.1309	0.00619		

* selected rank

```
. vecrank A_kg R_kg, trend(trend) lags(12)

Johansen tests for cointegration
Trend: Linear                                 Number of obs  = 922
Sample: 4/6/2008 thru 11/30/2025              Number of lags =  12
```

Maximum rank	Params	LL	Eigenvalue	Trace statistic	Critical value 5%
0	48	1402.354	.	13.5537*	18.17
1	51	1407.1066	0.01026	4.0484	3.74
2	52	1409.1309	0.00438		

* selected rank

Figure 13: Johansen cointegration test

The Johansen cointegration test results across all three specifications (restricted constant, restricted trend, and trend) indicate a rank of 0. Consequently, there is no evidence of a long-run relationship between the prices of Arabica and Robusta

Short-run relationship: Granger Causality test

```
. vargranger

Granger causality Wald tests
```

Equation	Excluded	chi2	df	Prob > chi2
D_A_kg	D.R_kg	47.961	12	0.000
D_A_kg	ALL	47.961	12	0.000
D_R_kg	D.A_kg	31.102	12	0.002
D_R_kg	ALL	31.102	12	0.002

Figure 14: Granger Causality test

- We can reject the null hypothesis that D.R_kg does not Granger-cause D.A_kg ($p-value = 0.000$) $\rightarrow$ D.R_kg Granger-cause D.A_kg
- We can reject the null hypothesis that D.A_kg does not Granger-cause D.R_kg ($p-value = 0.002$) $\rightarrow$ D.A_kg Granger-cause D.R_kg

Conclusion: The results show two-way Granger causality between the variables. Changes in Robusta prices Granger-cause changes in Arabica prices, and changes in Arabica prices also Granger-cause changes in Robusta prices.

iv. Restrict the sample to the period 2008–2022 using: keep if tin(, 25dec2022) Re-run the Johansen test and interpret the results. Based on your interpretation, suggest the appropriate modeling approach for these two variables and perform it.

```
. varsoc A_kg R_kg if tin(,25dec2022), maxlag(12)

Lag-order selection criteria

   Sample: 4/6/2008 thru 12/25/2022                        Number of obs = 769
  +---------------------------------------------------------------------------+
  | Lag |    LL      LR      df    p     FPE      AIC       HQIC      SBIC     |
  |-----+---------------------------------------------------------------------|
  |   0 |  -1048.7                      .052702   2.73265    2.7373   2.74473  |
  |   1 |  1601.41  5300.2    4  0.000 .000054  -4.14932  -4.13537* -4.11308* |
  |   2 |  1605.31  7.7854    4  0.100 .000054  -4.14904  -4.12579  -4.08864  |
  |   3 |  1608.55  6.4948    4  0.165 .000054  -4.14708  -4.11454  -4.06252  |
  |   4 |  1617.28  17.444*   4  0.002 .000054* -4.15937* -4.11752  -4.05064  |
  |   5 |  1621.12  7.6952    4  0.103 .000054  -4.15897  -4.10782  -4.02608  |
  |   6 |  1622.73  3.2102    4  0.523 .000054  -4.15274   -4.0923  -3.99569  |
  |   7 |  1624.26  3.0716    4  0.546 .000054  -4.14633  -4.07659  -3.96512  |
  |   8 |  1628.85  9.1719    4  0.057 .000054  -4.14786  -4.06881  -3.94248  |
  |   9 |  1631.53  5.3507    4  0.253 .000054  -4.14441  -4.05607  -3.91487  |
  |  10 |  1633.45  3.8473    4  0.427 .000055  -4.13901  -4.04137  -3.88531  |
  |  11 |  1635.27  3.6422    4  0.457 .000055  -4.13334   -4.0264  -3.85548  |
  |  12 |  1638.71  6.8763    4  0.143 .000055  -4.13188  -4.01564  -3.82986  |
  +---------------------------------------------------------------------------+
   * optimal lag
   Endogenous: A_kg R_kg
    Exogenous: _cons
```

Figure 15: varsoc A and R

AIC smallest at lags 4 $\rightarrow$ the optimum lag length is 4

Long-run relationship: Johansen cointegration test

```
. vecrank A_kg R_kg if tin(,25dec2022), trend(rconstant) lags(4)

Johansen tests for cointegration
Trend: Restricted constant                 Number of obs  = 777
Sample: 2/10/2008 thru 12/25/2022          Number of lags =   4
---------------------------------------------------------------
                                                      Critical
Maximum                                      Trace       value
   rank  Params        LL   Eigenvalue   statistic         5%
      0      12   1590.4371          .     16.8358*      19.96
      1      16   1596.1465    0.01459      5.4171        9.42
      2      18    1598.855    0.00695
---------------------------------------------------------------
* selected rank
```

```
. vecrank A_kg R_kg if tin(,25dec2022), trend(rtrend) lags(4)

Johansen tests for cointegration
Trend: Restricted                          Number of obs  = 777
Sample: 2/10/2008 thru 12/25/2022          Number of lags =   4
---------------------------------------------------------------
                                                      Critical
Maximum                                      Trace       value
   rank  Params        LL   Eigenvalue   statistic         5%
      0      14   1590.5268          .     16.8225*      25.32
      1      18   1596.2026    0.01450      5.4710       12.25
      2      20   1598.9381    0.00702
---------------------------------------------------------------
* selected rank
```

```
. vecrank A_kg R_kg if tin(,25dec2022), trend(trend) lags(4)

Johansen tests for cointegration
Trend: Linear                              Number of obs  = 777
Sample: 2/10/2008 thru 12/25/2022          Number of lags =   4
---------------------------------------------------------------
                                                      Critical
Maximum                                      Trace       value
   rank  Params        LL   Eigenvalue   statistic         5%
      0      16   1590.6621          .     16.5520*      18.17
      1      19   1596.2288    0.01423      5.4187        3.74
      2      20   1598.9381    0.00695
---------------------------------------------------------------
* selected rank
```

Figure 16: Johansen cointegration test (2008–2022)

The Johansen cointegration test results across all three specifications (restricted constant, restricted trend, and trend) indicate a rank of 0. Consequently, there is no evidence of a long-run relationship between the prices of Arabica and Robusta.

Short-run relationship: Granger Causality test

```
. vargranger
```

Granger causality Wald tests

Equation	Excluded	chi2	df	Prob > chi2
D_A_kg	D.R_kg	6.8884	4	0.142
D_A_kg	ALL	6.8884	4	0.142
D_R_kg	D.A_kg	4.314	4	0.365
D_R_kg	ALL	4.314	4	0.365

Figure 17: Granger Causality test (2008–2022)

- We cannot reject the null hypothesis that D.R_kg does not Granger-cause D.A_kg ($p-value = 0.142$) $\rightarrow$ Robusta prices do not cause Arabica prices.
- We cannot reject the null hypothesis that D.A_kg does not Granger-cause D.R_kg ($p-value = 0.365$) $\rightarrow$ Arabica prices do not cause Robusta prices.

  Conclusion: The results confirm that there is no Granger causality in either direction between the two markets during this specific period (2008–2022).

3 Question 3

i. What is the main research question of the paper? What are the three key variables studied? Which variables are endogenous and which are exogenous?

- The main research question is to measure the effects of monetary policy on the Vietnamese economy. Three key variables are interest rate, aggregate price, and output.
- Endogenous variables include Industrial production index, Consumer price index, Broad money, Central Bank policy rate, Total domestic credit, and Nominal exchange rate.
- Exdogenous variables are World oil price, and Chinese lending rate.

ii. What are the stationarity properties of the variables? How did the authors handle seasonal adjustment of the data?

- Broad money, total credit, and the Chinese lending rates are stationary at level; the five other time series are stationary at first difference.
- The authors detected seasonality by regressing each variable on seasonal dummy variables and a yearly time trend. Additionally, the alternative solution, which uses a complete set of monthly dummy variables in the VAR models to deal with seasonality.

$$Y_t = c_0 + qYear_t + \sum_{i=1}^{11} m_i D_{it} + \epsilon_t$$

iii. Which model is used in the study – VAR or SVAR? What method is employed to identify the non–white-noise residual matrix u_t?

- Model used in the study is VAR. Method employed is to identify the non-white-noiseresidual matrix u_t is Cholesky decomposition of endogenous variables. The authors choose Cholesky decomposition because it imposes fewer restrictions.

iv. Is this methodology purely atheoretical, or does it rely on theoretical a priori assumptions?
It is not purely atheoretical, it based on theoretical framework and Granger-causality test.

- According to Christiano, Eichenbaum, and Evans (2005); Kim and Roubini (2000); Elbourne and de Haan (2009); Raghavan, Silvapulle, and Athanasopoulos (2012), the linkages between these variables: IPI → CPI & M2 → Interest rate → Credit → Exchange rate.

- The Granger-causality test also shares the same results, IPI, CPI Granger-cause M2, Inte, EXC. M2 Granger-causes Inte and EXC at the 10% significance level and Cred at the 1% significance level. Inte Granger-causes Cred at 1% significant level. EXC is Granger-caused by almost all variables (IPI, CPI, M2, Cred)

- Althought the variables are integrated of differences order, the authors use VAR model. According to Lütkepohl (2005), the overall stationarity condition of a VAR model is more important than the stationarity of all single series.

v. Summarize the effect of a monetary policy shock on inflation and national output based on the impulse response functions.
Response of National Output (Industrial Production): The analysis indicates that national output largely unresponse to monetary shocks in the short run, except money supply.

- **Broad Money Supply** There is no impact during the first quarter (0–3 months), but a statistically significant positive effect from the 4th month onwards.

- **Other Variables** Shocks to the interest rate, exchange rate, and credit do not statistically significant.

Response of Price Level: The price level sensitive to monetary instruments

- **Interest rate** A shock to the interest rate has a significant negative effect on prices starting from the 3rd month and persisting until the 20th month. → monetary reduces inflation

- **Log of exchange rate** Shock to exchange rate do not statistically significant

- **Log of broad money** The effect is statistically insignificant for the first two years (approx. 24 months), with a positive effect appearing only after the 26th month. → The money supply increase price level in long-term

- **Log of credit** a shock to the credit level leads to a negative response in prices, which is statistically significant between the 2nd and 30th months.