The lead lag relationship between oil prices and exchange rate in an oil importing country: evidence fromThailand using ARDL

Tayeb, Hamza and Masih, Mansur

INCEIF, Malaysia, INCEIF, Malaysia

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Hamza Tayeb[1] and Mansur Masih[2]

Abstract:

The purpose of this study is to explore the Granger-causal relationship between oil prices, exchange rates and inflation rates using Thailand as a case study. Discerning this relationship will help us understand the mechanics of the Thai economy and the factors contributing to its development. Standard time-series and ARDL methods were used to investigate this relation. The reason for choosing to apply both methods is that ARDL is a more robust technique than the standard time series technique. Also, ARDL helped us overcome a problem regarding the variables used in the study as we had a mix of I(0) and I(1) variables which is unacceptable under the standard time-series technique when cointegration of the variables is examined. Our empirical findings tend to indicate that there is a long run relationship existing between these variables and that the exchange rate appears to be the variable leading oil prices and inflation at least in the context of Thailand during the period under review. The results are reasonable and have strong policy implications.

Key Words:

Oil Price, Exchange Rate, Inflation, Thailand, cointegration, exogeneity, endogenei

[1]Graduate student in Islamic finance at INCEIF, Lorong Universiti A, 59100 Kuala Lumpur, Malaysia.

[2] **Corresponding author**, Professor of Finance and Econometrics, INCEIF, Lorong Universiti A, 59100 Kuala Lumpur, Malaysia. Email: mansurmasih@gmail.com

Introduction:

The oil industry has been a major player in the world's economy. The fluctuations in the prices of this commodity affects countries' economic conditions regardless of their position as an oil importing or exporting countries. Rising or declining oil prices can result in changing the trade balance of oil exporting countries which eventually affect their exchange rates. For importing countries, changing oil prices affects the cost of production, making it more expensive if oil prices rise and lower if the prices decline, thus affecting the product output of that country.

As a result of its major role of oil in the world economy, many studies have been conducted to analyze the effect of oil prices on various economic variables like GDP and inflation especially after the 1973. Firstly, Hamilton (1983), concluded that oil prices shocks have a great impact on the world economy. Additionally, he stated that the main cause of recessions that came after the second World War was high oil prices. After that other researchers like Gisser and Goodwin (1986), Burbridge and Harrison (1984), and Cunado and Perez de Gracia (2003) have reached the same conclusion but with different data sets. However, other studies suggested that the oil price-macroeconomy relationship has weakened since 1986 after the collapse of the oil prices, but Hooker (1996) still showed that the relationship still exists and oil prices can affect business cycles.

For developing economies, oil is a vital element in the production process. In developing countries like Turkey, Indonesia, South Africa and Thailand, oil imports take a big portion of their total imports. Thus, fluctuations in the oil prices will certainly impact their economies. Studies have found that increasing oil prices will lead to higher production costs leading to higher prices of the commodities if the rise in oil prices is passed to the consumers. This can also affect the level of the countries' exports, leading it to decline as because of the increase in the domestic prices compared to the foreign competitors.

This paper will try to add to the literature on the relationship between oil prices and economic variables of Thailand. This study will try to find if oil prices drive movements of the Thai exchange rate and inflation rates of the country. There is not much studies conducted on how does the oil price shocks affect the GDP, inflation, and exchange rate of Thailand. It is important to understand this relationship since Thailand is considered an oil importing country. In 2017, Thailand's mineral fuel imports including oil equaled 31.6 billion US Dollars ranking it the second in the list of the top ten imports of Thailand.

The objective of this paper is to find out if the oil prices leads the exchange rate movements using the example of Thailand. Additionally, the paper aims to examine the long run relationship between oil prices, households' consumption, inflation, and exchange rates of Thailand using the time-series method. Lastly, the study will examine the effect of these relations on the Thai economy and analyze the policy implications of the results.

Section 2 of the paper will discuss the previous literature on the topic. Section 3 includes the data and methodology approach used in this study. Section 4 is the discussion of the results derived from the previous section. Lastly, section 5 includes the conclusion and proposed recommendations of the paper.

Literature Review:

It has been well established theoretically and empirically that oil prices shocks can have an effect on countries exchange rates. The effect is even more significant in the economies of oil dependent countries; however, the effect is different for an oil importing and oil exporting countries. In case the demand is inelastic, an increase(decrease) in an importing(exporting) good price will lead to depreciation in the value of the currency as a result of decline in the trade balance. Several studies have been conducted to examine the relationship between oil prices and exchange rates.

A study that was conducted by Chen, Liu, Wang, and Zhu on the long-term relationship between oil prices and exchange rates in 16 OECD countries found that oil prices shocks can explain 10% of the short-term variation of exchange rates and 20% of the long-term exchange rates. Additionally, Jehle and Reny propose that the effects of an oil shock in an importing country depends on the elasticity of imports demand of the countries. Meaning that an oil price increase will have a strong economic impact on the value of the currency only if there is a lower response of domestic demand to price changes.

Other studies have been conducted to examine the difference of the oil price shocks on an oil importing and an oil exporting country. In a study conducted by Azman Aziz where the long run effect of real oil prices on real exchange rates was examined using a monthly panel of 8 countries from 1980 to 2008. the paper finds that there is a positive and statistically significant impact of real oil price on exchange rate for net oil importing countries, meaning that an increase in oil prices will lead to a depreciation in the real value of the currency, however, the paper did not find any long run relationship between real oil prices and real exchange rates in oil exporting countries. Similarly, in a study conducted by Stavros, George, and Christos examining the effect of oil prices on exchange rates in oil importing and oil exporting countries. The results suggest that in oil importing countries a supply side shock in oil does not affect oil importing countries' exchange rates however, it leads to an appreciation of the oil exporting currency.

However, some studies have found that there is not any long-run relation between oil prices and exchange rates. In a study conducted on Romanian economy by Ahmet Shabaz, the results indicate that oil price shocks do not have a significant impact on the Romanian exchange rate.

In this paper, we will try to analyze whether oil prices and exchange rates have a long-run relationship in an economy of an oil importing country. Also, the study will examine the Granger causality relation between oil prices, exchange rates, households' consumption, and inflation.

Data and Methodology:

- Data and Variables:

In this paper, we use quarterly data from 1993 till 2017. All variables data are collected from DataStream. In this paper four variables were used which are exchange rate, oil prices, inflation, and household' consumption. The following table shows the description of the used variables.

Variable	Definition
ER	Exchange rate of Thai Bhat (value of one US Dollar in terms of Thai Baht)

OIL	Oil Prices per barrel, West Texas Intermediate
INF	Consumer Price Index used as inflation rate
HH	Households' Consumption

- Methodology:

The paper uses the standard time series technique to analyses the long run relationship between the variables. Firstly, the Phillips-Perron test is applied to check for stationarity of the variables. After that, the VAR is examined to identify the lag orders to be used in the third test which is the cointegration test. Two tests were used to test for cointegration which are Engle-Granger test and Johansen's test. After examining cointegration, LRSM was applied to quantify the long run relationship by testing the long-run relation between the variables and theoretical foundations. After that VECM was used to find the exogeneity and endogeneity of the variables, however VDC was used to identify the relative exogeneity and endogeneity relation of the variables. Lastly, IRF and PP were used to examine the impact of a variable specific shock and system-wide shock on other variables. The results of the last test were demonstrated in graphs.

Results and Discussion:

Unit Root Test:

In the standard time series technique, the initial stage is checking the stationarity of the variables. It is important to check for stationarity because statistical tests cannot be performed when the variables used are non-stationary. If the variables are non-stationary and cointegrated, the resulting regression is incorrect because of the biased coefficients and error terms. However, if the variables are non-stationary but not cointegrated the ordinary regression can be used with the differenced form of the variables, making them stationary. Nevertheless, the long run relationship between the variables cannot be estimated and the conclusion will apply to the short-term period. Stationarity basically means the variance, mean, and covariance being constant with the variables lags. A non-stationary variable is a variable where its mean, variance, and covariance with its lags are not constant. Additionally, in stationarity, coefficients of autocorrelations die down quickly after significant lags however, in non-stationarity those the coefficients tend to move in unison. Usually variables are non-stationary in their log forms and become stationary after being differenced one time. There are different types of stationarity tests like the Augmented Dickey-Fuller test, Schmidt-Philips test, the Philips-Perron test and others. In this study we use the Philips-Perron test to identify the stationarity and non-stationarity of the variables used. The Philip-Perron (PP) test is a modification of the Augmented Dickey-Fuller test as it corrects for both autocorrelation and heteroskedasticity in the errors. The following tables shows the results of the PP test.

Variable	Test Statistic	Critical Value	Result
Log Form			
LER	-1.7666	-3.4243	Non-Stationary
LOIL	-2.0244	-3.4243	Non-Stationary
LINF	-3.0913	-3.4243	Non-Stationary
LHH	-5.3729	-3.4243	Stationary
Difference Form			
DER	-8.9036	-3.4268	Stationary
DOIL	-10.1852	-3.4268	Stationary
DINF	-12.8538	-3.4268	Stationary
DHH	-12.5337	-3.4268	Stationary

Note: the null hypothesis for the Phillips-Perron (PP) test is that the variable is non-stationary.

The results in the table show that all variables are non-stationary in their log form and become stationary in their first difference form except for HH (household's consumption).

VAR Order:

In this step we will identify the lag order using the Unrestricted VAR estimation. The lag order is important to identify before moving to the cointegration test. The following table shows the results of the test. The lag order is selected by looking at the maximum values of AIC and SBC. AIC tends to overfit the model, whereas SBC tends to underfit the model. The table shows that 2 lag orders should be used according to AIC and 0 lag orders according to SBC. We choose to move with 1 lag order in the study.

	AIC	SBC
Highest Value	829.1773	834.1129
Optimal Order	2	0

Cointegration Test:

After identifying the lag orders, we move to the cointegration test. The cointegration test is used to find if there is a long-term relationship between the variables. Basically, cointegration is an explanation of the relationship between variables. Technically, cointegration happens when the mean distance between two variables tend to be constant, or predictable. In other words, variables are cointegrated when they tend to move together.

In this study we employ two cointegration tests which are the Engle-Granger test and Johansen's test. The E-G test uses the residual based approach and can identify only one cointegration however, Johansen's test uses the maximum likelihood approach and can identify more than one cointegration.

- E-G Test

The following table shows the results of the E-G test. The null hypothesis in this test is that there is not cointegration. The results show that the there is no cointegration as the t-statistic is less than the critical value.

	T-statistic	C.V	Result
ADF (1)	-3.3875	-4.2167	No Co-integration

- Johansen Test

In the Johansen test two tables are used to extract the relation between the variables. The tables are Maximal Eigenvalue and the Trace table. Both tables should indicate a cointegration otherwise the null hypothesis will be accepted. Both tables show that there is only one cointegration between the variables.

Cointegration LR Test Based on Maximal Eigenvalue of the Stochastic Matrix

	Alternative	Statistic	95% Critical Value	90% Critical Value
r = 0	r = 1	47.4416	31.79	29.13
r<= 1	r = 2	17.0174	25.42	23.1

Cointegration LR Test Based on Trace of the Stochastic Matrix

Null	Alternative	Statistic	95% Critical Value	90% Critical Value
r = 0	r>= 1	76.2108	63	59.16
r<= 1	r>= 2	28.7692	42.34	39.34

Cointegration test using ARDL:

ARDL technique was used to test for cointegration. As the results show in the unit root test, one of the variables was stationary in its log form, which can be a problem when applying the E-G and Johansen test. The problem arises as in those two tests it is required to have variables that are stationary at first difference I (1), however ARDL allows for the data to have a mixed set of I (0) and I (1) variables.

Under ARDL, the F-test is the way to test for cointegration between the variables. The basic concept of it is to examine the collective effect of variables on the chosen dependent variable. Thus, in this test, it is needed to form different models, as the dependent variable change with every model.

The null hypothesis in the F-test states that there is no cointegration between the variables, whereas the alternative hypothesis states that there exists long-run relationship between the variables. The critical values given by Pesaran et al (2001) are used in comparison to the computed values of the F-test to reach a decision on whether the variables are cointegrated or not. If the computed value if higher than the upper bound value from the F table of Pesaran, we can reject the null hypothesis which means that there is a long run relationship, however if the computed value is lower than the tabulated value then we fail to reject the null hypothesis indicating that there is no long run relationship between the variables. In case the F-test value falls within the lower and upper bound then the result is inconclusive.

The following table shows the results of the F-test. The results reveal that only one of the 4 estimated models are cointegrated as only one model have valued F-statistics well above the upper bounds of critical value at 95% significance level (2.850 – 4.049). When Inflation is set a dependent variable, it shows that there is a cointegrating relationship between the variables. However, when Exchange rates, household's consumption, and oil prices were taken as dependent variables, there was no evidence of the existence of a cointegrating relationship as the calculated F-statistic (1.8978), (0.9698), (2.3354) respectively fall below the lower bound.

Models	F-statistics
FLER (LER | LINF, LHH, LOIL)	1.8978
FLINF (LINF | LER, LHH, LOIL)	4.4435
FLHH (LHH| LER, LOIL, LINF)	0.9698
FLOIL (LOIL | LER, LHH, LINF)	2.3354
F-stat- Lower bound: 2.850 Upper bound: 4.049 At 95%	

Estimated Long-Run Coefficients of ARDL:

The previous test indicates the long-run relationship between the variables but it does not indicate the relevant coefficients of the variables. In this stage we try to estimate the coefficients of the long-run relations and make inferences about their values using ARDL. In other words, it does not quantify the relationship between the variable, thus this step is used to identify the quantified theoretical relationship. It is important to note that at this stage it is only appropriate to assume that the long run relationship between the variables is not false.

The following table shows the corresponding for the variables with considering different models. It is important to note that the model where inflation is set as the dependent variable is the only one that has all significant coefficients for the independent variables. The table shows that there is a long run relationship between exchange rate and inflation. The relationship between the two variables is negative at 5%. That means a 1% increase in inflation would decrease the value of the Thai Bhat by 2.8769%. This supports several studies such as Pearcy, J. (1984), Gordon, R. J. (1981), and others. Therefore, inflation plays an important part in determining a country's currency value.

However, when inflation is set as the dependent variable, we found that the relationship between it and exchange rates is positive which is contradicting to the first model in which the exchange rate is set as the dependent variable. It assumes that a 1% increase in inflation leads to a 0.06025% increase in the value of the Bhat. Also, the results show a positive relationship between oil prices and inflation rates. According to the second model, a 1% increase in oil prices will lead to a 0.09697% increase in inflation rates which similar to what Cunado, J., & De Gracia, F. P. (2005) have found in their study. Lastly, for the households' consumption and inflation the result shows a positive relationship between the two variables. This means a 1% increase in household's consumption will lead to 0.42899% increase in inflation.

	LER	LINF	LOIL	LHH
k	Model 1	Model 2	Model 3	Model 4
LER		0.060025**	-0.67142	0.58655
LINF	-2.8769**		3.9638**	-0.10116
LOIL	0.28552	0.096971**		0.088005*
LHH	2.0563	0.42899***	-0.47966*	
INPT	-20.3455	-1.5511*	-9.9251	16.6037

*Significant at 10%
**Significant at 5%
***Significant at 1

Error Correction Modeling of ARDL:

The previous tests of cointegration did not indicate the lead-lag relationship between the variables. By identifying this relationship will be able to which variable is the leader (exogenous) and which variable is the follower (endogenous). The error correction modelling technique was applied to find the exogenous and endogenous variables. Since there could be a short-run deviation from the long-run equilibrium. Cointegration does not reveal the progression of short-run adjustment to bring about the long-run equilibrium. To reach an understanding of the adjustment process we need to proceed to the error-correction model.

The following table indicates the results of the ECM. By observing the P-values of the error correction coefficients, we can conclude that both exchange rate and oil prices are the exogenous variables, whereas the endogenous variables are household consumption and inflation. The exogenous variables would receive market shocks and convey the effects of those shocks to the other variables. This means when exchange rate and oil prices are shocked which are shown to be the leader variables, the followers like households' consumption and inflation will be affected. Therefore, it is crucial for policymakers to carefully monitor those variables that will have a profound effect on the country's economy as a whole. The coefficients values show the speed of the short-run adjustment that brings the long-run equilibrium. The error correction model also can differentiate between the short-run and long-run Granger causality.

ecm1(-1)	Coeffecient	Standard Error	T-Ratio[Prob]	C.V	Result
dLER	-0.056326	0.030253	-1.8618[.066]	5%	Exogenous
dLHH	-0.12375	0.05016	-2.4672[.015]	5%	Endogenous
dLINF	-0.058266	0.015995	-3.6429[.000]	5%	Endogenous
dLOIL	0.0065558	0.026733	.24524[.807]	5%	Exogenous

Variance Decompositions of ARDL:

In the previous step in which we examined the lead-lag relationship between variables, we concluded that exchange rate and oil are exogenous and household consumption and inflation are endogenous, however, we did not indicate the relative endogeneity and exogeneity of the variables. The relative endogeneity indicates which variable is the most exogenous and which variable is the most endogenous. VDC is used to determine the relative relationship. VDC decomposes the variance of forecast error of the variables into proportions attributable to shocks from each variable in the system including the shocked variable. By doing that we can tell how much each variable is explained by its part values. Consequently, the most exogenous variable is the one that is mostly explained by its own past, and the most endogenous is the one that is explained the least by its own past.

Under VDC, there are two methods to measure the relative exogeneity and endogeneity which are the orthogonalized and the generalized. In the orthogonalized method, the order of the variables plays a role in the determining the relative exogeneity and endogeneity. Meaning that the variable that is put in the beginning is probably to be the most exogenous variable, and the last one will be considered as the least exogenous. However, in the generalized, the order is not important. Also, in the orthogonalized method, when one variable is shocked, other variables are switched off meaning that the impact of the shock is not examined on the other variables, however in the generalized this assumption is relaxed. The following tables show the results of both orthogonalized and generalized VDC.

- Orthogonalized

	Horizon	LHH	LER	LOIL	LINF	Total	Rank
LHH	4	100.00%	0.00%	0.00%	0.00%	100.00%	1
LER	4	9.27%	90.68%	0.01%	0.04%	100.00%	3
LOIL	4	5.10%	0.19%	94.71%	0.00%	100.00%	2
LINF	4	1.75%	0.34%	12.71%	85.20%	100.00%	4

	Horizon	LHH	LER	LOIL	LINF	Total	Rank
LHH	8	99.98%	0.01%	0.00%	0.01%	100.00%	1
LER	8	7.36%	92.48%	0.02%	0.13%	100.00%	3
LOIL	8	5.78%	0.16%	94.05%	0.01%	100.00%	2
LINF	8	7.50%	0.44%	11.96%	80.11%	100.00%	4

	Horizon	LHH	LER	LOIL	LINF	Total	Rank
LHH	12	99.97%	0.01%	0.00%	0.02%	100.00%	1
LER	12	5.87%	93.81%	0.04%	0.28%	100.00%	2
LOIL	12	6.44%	0.13%	93.40%	0.03%	100.00%	3
LINF	12	18.89%	1.03%	10.40%	69.67%	100.00%	4

- Generalized

The tables show the ranking of the variables according to their exogeneity and endogeneity. We examined this relation through three different horizons to test whether the rankings will change over time or not. According to the tables exchange rate is the most exogenous variable with 90.03%, followed by oil prices with 87.65%, and inflation by 86.78%, and lastly household consumption by 83.19%. This percentages indicate the contribution of each variable's own shock towards explaining the forecast error variance of each variable. Meaning that that variables with the highest percentage is the most one which is explained by its own past. This holds true as the exchange rate has the highest percentage indicating that it is the most exogenous and household consumption is the least exogenous by having the lowest percentage. The rankings do not change when examining different horizons.

According to the results, an increase in exchange rates will lead to an increase in oil prices in Thailand as it is an oil importing country. Consequently, rising oil prices will lead to an increase in inflation indicating an increase in goods prices resulting from the increase of production costs. Households consumption will decrease as a result of the increase in goods prices.

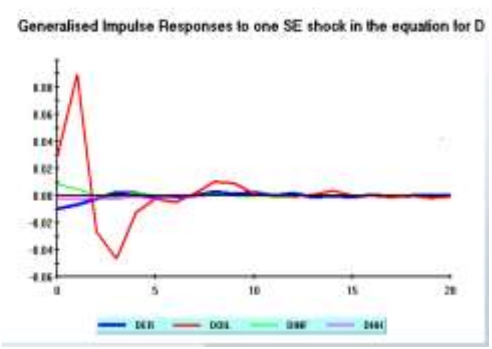
	Horizon	LHH	LER	LOIL	LINF	total	Rank
LHH	4	83.19%	9.87%	3.61%	3.34%	100.00%	4
LER	4	8.37%	90.03%	0.05%	1.55%	100.00%	1
LOIL	4	4.47%	0.12%	87.65%	7.76%	100.00%	2
LINF	4	1.59%	0.81%	10.82%	86.78%	100.00%	3

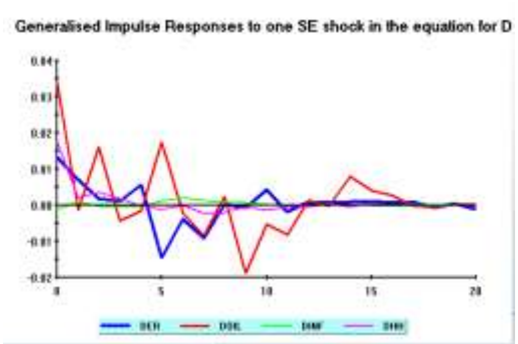
	Horizon	LHH	LER	LOIL	LINF	Total	Rank
LHH	8	82.97%	10.01%	3.54%	3.47%	100.00%	3
LER	8	6.84%	91.95%	0.04%	1.17%	100.00%	1
LOIL	8	5.06%	0.19%	87.44%	7.31%	100.00%	2
LINF	8	7.03%	2.13%	12.71%	78.14%	100.00%	4

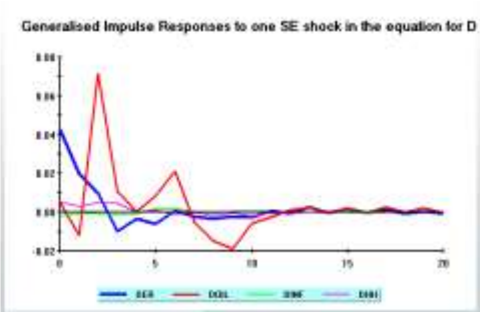
	Horizon	LHH	LER	LOIL	LINF	Total	Rank
LHH	12	82.77%	10.15%	3.49%	3.59%	100.00%	3
LER	12	5.61%	93.46%	0.04%	0.90%	100.00%	1
LOIL	12	5.64%	0.27%	87.19%	6.90%	100.00%	2
LINF	12	17.78%	5.50%	13.26%	63.46%	100.00%	4

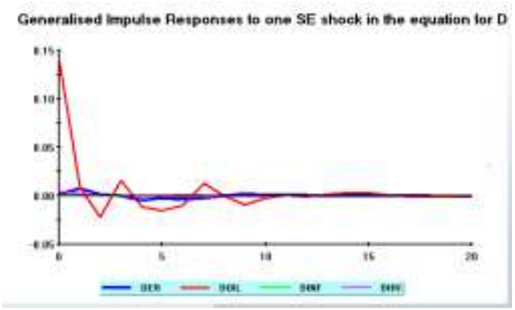
Impulse Response Functions (IFR) of ARDL:

The impulse response function test shows the same results as the previous test; however, the results can be illustrated in graphical form. Similar to VDC, there is orthogonalized and generalized IFR, and the differences between both are similar to the differences between the orthogonalized and generalized VDC. Using the following graphs, we can conclude the effect of a shock on variable on other variables.





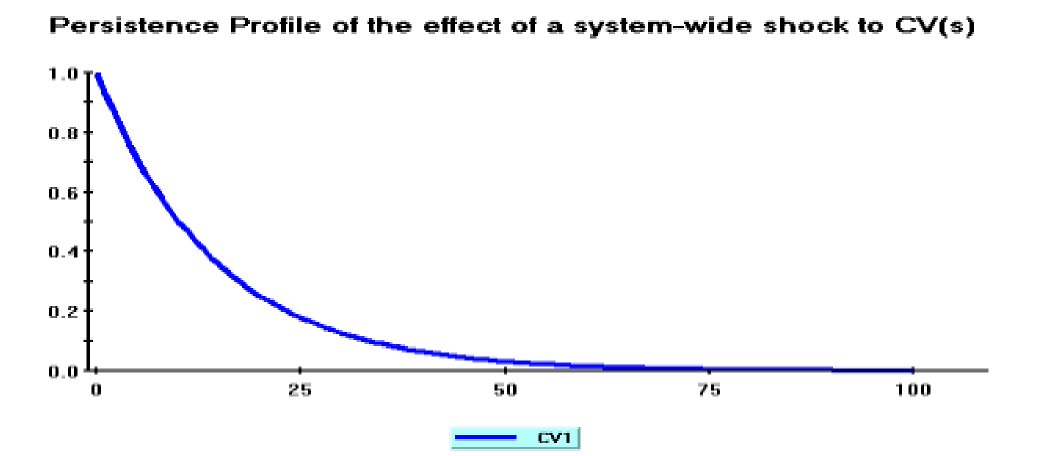




Persistence Profile:

In this step we examined the impact of a system-wide shock on the cointegrating relation between the variables and the time it would take for the relationship to return to equilibrium. As opposed to the previous test of IFR where the impact of a shock to one variable is examined, in PP the impact of a shock to the whole system is tested. The following graph shows the persistence profile for the cointegrating equation of the study.

It can be concluded that it will take 50 quarters (12.5 years) for the cointegrating relation to return to equilibrium and recover from a system-wide shock.



Conclusion and Policy implications:

This study examines the lead lag relationship between exchange rates, oil prices, household's consumption, and inflation rates using the data of Thailand as an oil importing country. Standard time series and ARDL techniques were used to examine the long run relationship between the variables. A cointegration test was employed to identify the availability of a theoretical long run relationship between the variables. Additionally, other techniques like LRSM, VECM, and VDC were used to test for the causality relationship between the variables, and the relative exogeneity and endogeneity relation. Our results indicate that exchange rates and oil prices are exogenous while household's consumption and inflation are endogenous. Also, through VDC, we found that exchange rate is the most exogenous variable among the four variables meaning it is the variable mostly explained by its own past in comparison to other variables. Oil price is the second most exogenous variable and household's consumption comes last. In the LSRM step, we found that inflation is negatively correlated with exchange rates which holds true according to the Purchasing Power Parity theory. Our study also shows that a shock to exchange rates will lead to an increase in oil prices which will automatically increase the costs of production in the country. Eventually households' consumption will be affected as a result of increased average prices of goods (inflation).

An implication that can be derived from this study is that the authorities in Thailand need to carefully monitor the exchange rates movements of the Thai Baht as it can affect other economic variables in the country. It is important to keep exchange rates in reasonable levels to limit the effect of oil price changes in the economy of Thailand. Changes in oil prices might lead to inflation through an increase in production costs in the country, which ultimately will result in a change in households' consumption behavior.

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