Would the volatility of oil price affect the GDP of a country ? Singaporean evidence

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Would the volatility of oil price affect the GDP of a country ? Singaporean evidence

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Abstract

Singapore is a small and open economy but is highly engaged in oil-related business. This study focuses on testing whether the volatility of oil price would affect the GDP of a country. Singapore is used as a case study. We used ARDL and Nonlinear ARDL for the analysis. Our findings are: i) There is a long-term correlation between Oil and GDP. ii) The Granger causality shows that GDP affects Oil rather than the other way around based on VDC of the ARDL. iii) NARDL shows a positive change in Oil does affect GDP in the long-run. However, a negative change is not significant. iv) There is a long-run asymmetry between Oil and GDP, but only symmetry in the short -run. v) The GDP will fluctuate positively and negatively in the short-run before coming back to equilibrium. Each of the results is given theoretical and logical interpretations.

Keywords: Oil price, GDP, ARDL, Nonlinear ARDL, VDC, Singapore

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Introduction:

Despite being only a small country with no natural resources, Singapore has achieved great economic success. Singapore's success can be attributed to many domestic and global factors. Owing to the fact that Singapore is a small and open economy, some researchers found that Singapore is highly correlated to other external market (Maysami & Koh (2000). Hence, it is important for us to see and analyse the impact of global factors on Singapore; namely changes in oil price.

Singapore is listed as the leading oil trading hub in Asia. According to the U.S. Department of Commerce's International Trade Administration, Singapore is ranked third in the world after New York and London, as an oil trading hub and amongst the world's top five oil refining centres (Export.gov, 2018).

According to US Energy Information Association (EIA), which is a dedicated website for energy-related information, Singapore is ranked third worldwide for exports of refined oil products in 2015 and has the world's largest bunkering port. Because Singapore has no natural resources, they had to import oil from other countries. In 2015, Singapore imported roughly 1 million barrels per day of crude oil; which is used in petrochemicals and refining sector (EIA.gov, 2018). While in 2016, Singapore exported $32.5 billion of refined petroleum, she imported $31.9 billion of refined petroleum and $13.9 billion of crude petroleum (OEC, 2018).

There are many papers that examined the relationship between Oil price and GDP of a country. However, the correlation or Granger-causal effect is unable to show that oil price can affect GDP. We attempt to give a solution for this issue by using ARDL and NARDL to show relationship and hopefully bring a new light to this controversy. This paper analyses two relationship using ARDL and NARDL regarding Singapore, namely i) Oil price and GDP ii) Tourism and GDP.

Due to data availability, we were unable to put tourism into our oil-GDP equation. We therefore assume that oil prices affect tourism through higher price of oil-related vehicle (e.g. Car, ships, aeroplanes) which will have an impact on travelling and tourism.

Our findings are: i) There is a long-term correlation between Oil and GDP. ii) The Granger causality shows that GDP affects Oil rather than the other way around based on VDC of the ARDL. iii) NARDL shows a positive change in Oil does affect GDP in the long-run. However, a negative change is not significant. Iv) There is long-run asymmetry between Oil and GDP,

but only symmetry in the short -run. V) The GDP will fluctuate positively and negatively in the short-run before coming back to equilibrium. VI) Possible factors for the GDP fluctuations are the theory of oil-trading theory, theory of Tourism-Led-Growth. VII) We also did cointegration test between Tourism and GDP, however the result was inconclusive. Hence it is in the appendix 2

Theoretical underpinning:

There are three main theoretical underpinnings used in this paper:

1) Oil does affect GDP and other macroeconomic variables through 'Increase in raw material'. When oil price increase, there is an increase in the price of manufacturing which requires oil. This will lead to an increase in all product which will increase inflation, reduce GDP, the change in these two variables will lead to a change in exchange rate currency as the capital inflow will be reduced based on the expectation of a 'lower return in investment'.
2) Interest rate should not affect inflation because Singapore adopts the 'exchange rate based monetary policy' where there is no intervention on interest rate. This is further emphasized by the Monetary Association of Singapore (MAS) where they said that there is no independent policy for interest rate. The interest rate of Singapore is highly correlated to the US interest rate or interbank rate. Thus, only exchange rate should affect inflation and not interest rate.
3) Oil price may not change the GDP of Singapore because Singapore is an oil-refinery country. Where they import oil then sells the refined oil to other countries. This will 'transfer' the effect of oil price changes to other countries. The revenue for Singapore from oil trading is basically derived from the difference between the cost of buying oil and the selling price of the refined oil. A change in oil price will change both the cost and selling price of oil; hence the impact on GDP may not be significant.
4) There is a direct and indirect impact of oil on Singapore. Direct impact is through the increase in raw materials, while indirect effect is between Singapore and their economic trading partners. This is because two of Singapore's major economic partners are Net Exporter countries; namely Malaysia and Indonesia. A positive change in price of oil will increase their income and indirectly will increase the demand for Singapore's goods by net exporter countries. Hence, a change in oil price maybe also benefit Singapore.

5) Oil will also have an impact of tourism as it will increase the cost of travelling. This is because most vehicles and transportations require oil to operate. Furthermore, because oil price affects inflation through increase in raw materials, it will increase the cost of living in Singapore. Hence, an increase in oil price will reduce tourism in Singapore.
6) Tourism is one of the factors of Singapore's income. This is because an increase in tourism will have few effects: 1) increase in products sold to tourist. 2) increase hotel revenue. 3) increase domestic and foreign investment as it signals that the economy is effective prospering. This phenomenon is called tourism-led-growth or LTG.

Literature Review

There are a lot of literatures that have researched about the effect of oil price or oil price shocks to economic variables. Amongst those literatures that found empirical evidence that oil price shocks affect GDP, output and inflations are Hamilton (2000), Kahn and Hamptom (1990) and Cross & Nguyen (2017). Some research extends the effect of oil price shocks on exchange rate. For example, Chen, Liu, Wang, & Zhu (2016) investigated 16 OECD countries and found that oil price shocks can explain 10% short-term variation in exchange rate and 20% long-term variation.

Unfortunately, there are some researches that failed to find the Granger cause for Oil price to macroeconomic variables when the sample period is above mid 1980s due to the nominal price decreases and market collapse in 1985 (Cunado & De Gracia, 2005). According to Lee et al. (1995) and Hamilton (1996), the relationship between oil price and macroeconomic variables are non-linear. They found that a decrease in oil will stimulate the economy, however, a similar increase in oil prices will have higher negative impact in economic activities. Ibrahim (2015) posits that the causes of asymmetry effects of oil price maybe due to public regulations and market structure. Furthermore, Shaobo Long & Jun Liang (2018) found that the relationship between oil price and inflation has diminished over the years.

Cunado & De Gracia (2005) examined the relationship between Oil prices, economic activity and inflation for certain Asian countries (which includes Malaysia and Singapore). However, they only found short-run relationship for Japan, South Korea and Thailand and no long-run cointegration relationship between oil and macroeconomic activities.

Oil price can also affect the overall trade deficit for oil importing countries. A growing trade deficit will generate expectations of future depreciation of the current exchange rate accompanied by higher inflation rate (Aloui, Safouane, & Aïssa, 2016).

Chang & Wong (2003) examined the relationship between oil price fluctuations and the Singapore economy. They found that oil price shock to Singapore economy is marginal and have insignificant adverse impact to Singapore's GDP, inflation and unemployment rate. The paper further contributes this phenomenon by stating the declining trend of oil intensity in Singapore since 1989 and the declining shares of the Singapore's expenditure on oil consumption as a percentage of its nominal GDP.

Abeysinghe (2001) found that oil price can affect Singapore's GDP both directly and indirectly through its trading partners. Malaysia and Indonesia are net oil export countries and major trading partners of Singapore. An increase in oil price will increase the revenue of Malaysia and Indonesia, which will then import more stuff from Singapore, thus increasing Singapore's GDP temporarily. However, as Indonesia and Malaysia start to feel the pinch, Singapore will experience a larger negative indirect effect.

The relationship between oil price and tourism is well documented and can be derived logically. Amongst the literatures that examined the relationship between tourism and oil price are Chatziantoniou & et., (2013), Beckens (2008, 2011).

The relationship between tourism and GDP is also discussed in the literature. In the case of Singapore, the tourism-GDP is still controversial. For example, Lee (2008) found that there is no cointegration among GDP and tourism, and the granger causality test shows that growth is the one leading the tourism. However, Katircioğlu (2011) shows that there is a long-run equilibrium between tourism and GDP, and that tourism leads growth.

4. Data and variables

The sample period is from January 1995 to May 2018, a total of 281 monthly observations. All of the data are extracted from Thomson Reuters Datastream. The long-run equilibrium relationship can be expressed in the following form.

$$GDP_t - \alpha_0 - \alpha_1 OIL_t - \alpha_2 CPI_t - \alpha_3 SBR_t - \alpha_4 EX_t = \epsilon_t$$

Where;

- **GDP =** Singapore's monthly Gross Domestic Product which is proxied by Industrial Production Index.
- **CPI =** Consumer price index is used as a proxy for Singapore's monthly inflation rate.
- **SBR=** Singapore's 3-month interbank rate (SIBOR), is used as a proxy for Singapore's monthly interest rate.
- **EX=** The exchange rate between Singapore and US. The exchange rate is in the form of USD/SGD for example 1USD = 1.37 SGD. This is used as a proxy for appreciation and depreciation of Singapore's currency.

5. Methodology and empirical results

Before we examine the cointegration of the variables, we need to test whether the variables are stationary or non-stationary, also known as the Unit Root Test. This is a commonly seen in most time-series literatures. This paper will use the three common techniques which are augmented Dicky-Fuller (ADF), Phillips-Perron (PP) and Kwiatkowski–Phillips–Schmidt–Shin (KPSS). Although each of these techniques is for testing Unit Root Test, they differ slightly between each other. The difference between ADF and PP is that ADF takes care of the auto-correlation, while PP takes care of auto-correlation and heteroscedasticity. In the case of KPSS, it differs from the previous two steps because it has a different null hypothesis. The null hypothesis for KPSS is that the variable is stationary. In contrast, ADF and PP has a null hypothesis that the variable is non-stationary.

	T<CV = NON. S					
	VARIABLE	*ADF*	*VALUE*	*T-STAT.*	*C.V.*	*RESULT*
LOG FORM	***LGDP***	ADF(5)=AIC	291.6011	-3.437	3.5067	Non-Stationary
		ADF(2)=SBC	281.9156	-3.8325	-3.4521	**Stationary**
	LCPI	ADF(3)=AIC	1104.9	-1.6186	-3.4397	Non-Stationary
		ADF(3)=SBC	1094	-1.6186	-3.4397	Non-Stationary
	LSBR	ADF(2)=AIC	138.8193	-1.5772	-3.4521	Non-Stationary
		ADF(1)=SBC	131.2321	-1.8345	-3.482	Non-Stationary
	LEX	ADF(1)=AIC	720.9941	-2.2989	-3.482	Non-Stationary
		ADF(1)=SBC	713.7606	-2.2989	-3.482	Non-Stationary
	LOIL	ADF(1)=AIC	221.2177	-2.0532	-3.482	Non-Stationary
		ADF(1)=SBC	213.9841	-2.0532	-3.482	Non-Stationary

Table 1: ADF test for log-form

The result from ADF is shown in Table 1. It is interesting to note that Singapore's GDP is stationary at level form as the T-stat is higher than the 5% critical value. This is similar to the finding of Aslanidis & Fountas (2014) and Narayan (2008) where they found that real GDP and Per Capita GDP is stationary in some countries. This ADF result shows that all the variables are non-stationary at level form, and stationary at first difference form (except for GDP in level form).

	T<CV = NON. S					
	VARIABLE	*ADF*	*VALUE*	*T-STAT.*	*C.V.*	*RESULT*
DIFF FORM	***DGDP***	ADF(4)=AIC	286.0511	-10.6768	-2.9093	Stationary
		ADF(1)=SBC	278.6847	-24.0658	-2.774	Stationary
	DCPI	ADF(5)=AIC	1102.2	-4.594	-2.9095	Stationary
		ADF(2)=SBC	1094.1	-6.8695	-2.8438	Stationary
	DSBR	ADF(1)=AIC	148.0045	-12.7927	-2.774	Stationary
		ADF(1)=SBC	142.5848	-12.7927	-2.774	Stationary
	DEX	ADF(3)=AIC	716.3123	-9.3059	-2.92	Stationary
		ADF(1)=SBC	710.4217	-12.2001	-2.774	Stationary
	DOIL	ADF(1)=AIC	219.4994	-11.8418	-2.774	Stationary
		ADF(1)=SBC	214.0797	-11.8418	-2.774	Stationary

Table 2: ADF test for first-difference form

Similar to the ADF test, we found that GDP is stationary at level form in PP and KPSS test also. The statistical result for PP and KPSS is the table 3.

	TS<CV= NON STAT			
	Variables	*T-STAT*	*CRIT V.*	*RESULT*
PP	***LGDP***	-14.7179	-3.4116	**Stationary**
	LCPI	-1.7174	-3.4116	Non-Stationary
	LSBR	-2.1615	-3.4116	Non-Stationary
	LEX	-1.9678	-3.4116	Non-Stationary
	LOIL	-2.0801	-3.4116	Non-Stationary
	DGDP	-62.8649	-2.865	Stationary
	DCPI	-20.3966	-2.865	Stationary
	DSBR	-16.8458	-2.865	Stationary
	DEX	-16.9377	-2.865	Stationary
	DOIL	-16.695	-2.865	Stationary

	TS<CV= NON STAT			
	Variables	*T-STAT*	*CRIT V.*	*RESULT*
KPSS	***LGDP***	0.10834	0.13666	**Stationary**
	LCPI	0.16837	0.13666	Non-Stationary
	LSBR	0.066499	0.13666	Non-Stationary
	LEX	0.14205	0.13666	Non-Stationary
	LOIL	0.16207	0.13666	Non-Stationary
	DGDP	0.066224	0.43385	Stationary
	DCPI	0.15511	0.43385	Stationary
	DSBR	0.13371	0.43385	Stationary
	DEX	0.18528	0.43385	Stationary
	DOIL	0.10888	0.43385	Stationary

Table 3: PP and KPSS test for log-form and first difference form

Cointegration test:

We did not apply for Johansen's test due to the limitations of the test itself. In our previous step, we found that our focus variable, GDP, is stationary at level form. Since Johansen requires all the variables to be integrated in the same order I(0), we cannot proceed with Johansen. Furthermore, the Johansen test is sensitive towards the number of Lags. We tried applying the Johansen test to our data and found different result based on the number of lags. The Johansen cointegration result is interpreted by looking at the statistic value and the critical value. If the Statistic is higher than the Critical Value, then we reject the null and accept the alternative. Table 4 shows the difference in the result with respect to the number of lags.

1 LAG

Maximal Eigenvalue of the Stochastic Matrix				
Null	**Alternative**	**Statistic**	**95% Critical Value**	**Result**
r = 0	r = 1	145.784	37.860	**More than 4 Cointegration**
r<= 1	r = 2	33.540	31.790	
r<= 2	r = 3	24.562	25.420	
r<= 3	r = 4	7.264	19.220	
r<= 4	r = 5	4.047	12.390	

Trace of the Stochastic Matrix				
Null	**Alternative**	**Statistic**	**95% Critical Value**	**Result**
r = 0	r>= 1	215.196	87.170	**2 Cointegration**
r<= 1	r>= 2	69.412	63.000	
r<= 2	r = 3	35.8725	42.340	

3 LAG

Maximal Eigenvalue of the Stochastic Matrix				
Null	**Alternative**	**Statistic**	**95% Critical Value**	**Result**
r = 0	r = 1	70.949	37.860	**2 CoinT.**
r<= 1	r = 2	32.581	31.790	
r<= 2	r = 3	20.775	25.420	

Trace of the Stochastic Matrix				
Null	**Alternative**	**Statistic**	**95% Critical Value**	**Result**
r = 0	r>= 1	133.866	87.170	**1 Coint.**
r<= 1	r>= 2	62.917	63.000	

Table 4: Sensitivity of Johansen with respect to the number of Lags

Hence, this paper will use Autoregressive distributed lags (ARDL) and Non-Linear ARDL (NARDL) as it could be applied to both I(1) and I(0) and bypass other limitations. ARDL was introduced by Pesaran et al. (2001) which is more advance time-series technique compared to the previous techniques; namely Engle Granger (1987) and Johansen (1991). The difference between ARDL and NARDL is that, ARDL assumes linearity and symmetry while NARDL does not.

There are few steps to do an ARDL and NARDL analysis. The first step is to find whether there exist a long-term cointegration amongst the variable in the equation or VAR which involves inspecting the 'error term' or the 'gap' among the variable. The F-test value is compared to the upper bound and lower bound critical value set by Pesaran et al (2001). If the F-value is higher than the upper limit, the variable is endogenous and there is cointegration. If the F-test is less than the lower bound, then it is insignificant and thus exogenous, but it does not result in "no cointegration". Only when all of the variables are insignificant or exogenous, then it can be said that there is no cointegration because all of the variables are moving independently. Additionally, the result is inconclusive if the F-value falls within the upper and lower bound.

The equation for ARDL can be written as the differenced variable + constant + all the differenced variables + all the logged variables.

VARIABLE	*SHORT TERM*	*LONG TERM OR "ERROR TERM"*	*F-VALUE*	*RESULT*
DGDP	DGDP INPT DGDP{1-4} DCPI{1-4} DSBR{1-4} DEX{1-4} DOIL{1-4}	LGDP(-1) LCPI (-1) LSBR (-1) LEX(-1) LOIL(-1)	1.2802	EXO
DCPI	DCPI INPT DGDP{1-4} DCPI{1-4} DSBR{1-4} DEX{1-4} DOIL{1-4}	LGDP(-1) LCPI (-1) LSBR (-1) LEX(-1) LOIL(-1)	6.994	ENDO
DSBR	DSBR INPT DGDP{1-4} DCPI{1-4} DSBR{1-4} DEX{1-4} DOIL{1-4}	LGDP(-1) LCPI (-1) LSBR (-1) LEX(-1) LOIL(-1)	1.8444	EXO
DEX	DEX INPT DGDP{1-4} DCPI{1-4} DSBR{1-4} DEX{1-4} DOIL{1-4}	LGDP(-1) LCPI (-1) LSBR (-1) LEX(-1) LOIL(-1)	3.7784	INCONCLUSIVE AT 10%
DOIL	DOIL INPT DGDP{1-4} DCPI{1-4} DSBR{1-4} DEX{1-4} DOIL{1-4}	LGDP(-1) LCPI (-1) LSBR (-1) LEX(-1) LOIL(-1)	4.1606	ENDO AT 10%

For FIVE VARIABLES	90%		95%		97.50%		99%	
	LOWER	**UPPER**	**LOWER**	**UPPER**	**LOWER**	**UPPER**	**LOWER**	**UPPER**
	2.782	**3.827**	**3.189**	**4.329**	**3.573**	**4.782**	**4.011**	**5.331**

Table 5: ARDL result and Pesaran's Critical bound

Our ARDL result is shown in table 5. The result shows that there is cointegration because there are at least two dependent variables; CPI and OIL which is significant at 1% and 10% respectively. The two independent variables are GDP and SBR, while EX is inconclusive at 10% significance level.

The result from ARDL is logical because Singapore has adopted the "Exchange Rate-based Monetary Policy" to effectively manage the inflation level or price stability in Singapore. This is an alternative to the conventional monetary policy which they would change the interest rate to effectively manage the country's inflation. Hence, our result is in-line with reality because interest rate is independent while inflation is dependent. Similar reasoning can be applied to why exchange rate to falls under the 'inconclusive' category. This maybe because exchange rate is mostly influenced by the market and sometimes the intervention from the Singapore government. It is important to note that under "Exchange Rate-based Monetary Policy", the exchange rate can still fluctuate due to the market, but not drastically because there is a 'policy band'. In simple terms, there is a limit for fluctuation of Singapore's exchange rate, and the 'limit' or policy band is periodically review (Monetary Authority of Singapore, 2018).

As for the exogeneity of GDP, it can be due to other global factors. Recall that Singapore is an open and small economy, the GDP of Singapore maybe affected by other factors like international trade, global risk and others which is not incorporated in our VAR. It is interesting to note that Oil is dependent at 10%, this maybe be caused by the change in the two exogenous variables (GDP and interest rate). Recall that Singapore is an oil-refining country. The price of oil might be affected GDP when the refining companies have higher productivity (which will increase the supply of refined oil, which will reduce the price of oil). Similarly, when interest rate of Singapore increases, the cost of borrowing for oil-refining companies are higher. This will result in higher cost of doing business, thus may affect the output of refined oil, thus changing the price of oil.

Once we established that there is cointegration in the long-run, we can proceed to the second step, which is Error Correction Model (ECM). In this step, we can find out the coefficient or the speed of adjustment of the variables in response to a disequilibrium in the variables. In simple terms, ECM can tell us how fast the dependant variable can 'react' to the change in the independent variable. It can also be interpreted as the short-run coefficient. The result of our ECM is shown in Table 6.

			Coefficient	[Prob]
LGDP	*AIC*	ecm(-1)	-0.41984	[.000]
	SBC	ecm(-1)	-0.40115	[.000]
CPI	*AIC*	ecm(-1)	-0.033471	[.000]
	SBC	ecm(-1)	-0.036082	[.000]
SBR	*AIC*	ecm(-1)	-0.035022	[.039]
	SBC	ecm(-1)	-0.030999	[.065]
EX	*AIC*	ecm(-1)	-0.020959	[.164]
	SBC	ecm(-1)	-0.021712	[.152]
OIL	*AIC*	ecm(-1)	-0.10422	[.000]
	SBC	ecm(-1)	-0.078295	[.000]

Table 6: ECM result based on ARDL approach

Based on the ECM result, we can know how each variable change in one month; because our data is monthly. We use both AIC and SBC for our reference, to get a better result. Firstly, each of the variable's coefficient is negative. This shows that there is a long term cointegration because each variable is moving to lessen the "Gap" or "error". In contrast, a positive coefficient means that the variable will move further from the equilibrium. According to the result, GDP changes by roughly 40% per month, followed by CPI by 33%, SBR by 30%, EX by 20% and OIL by 10%. Using this information, we can see how long it will take for a variable to fully correct itself back to the equilibrium. For example, GDP needs 2.5 months to achieve 100%, while Oil price needs roughly 10 months. All of the p-value are significant except for SBR and EX.

Although in ECM we can rank the exogeneity of the variables by the coefficient, a better method is to use Variance Decomposition (VDC). The main difference between the two steps is ECM is for the sample period, while VDC is a forecast outside the period. Where it shows

the relative exogeneity of each variable after a set of horizon or period. Table 7 shows the result for our VDC.

HORIZON		GDP	CPI	SBR	EX	OIL	TOTAL
5	GDP	94.86	1.57	0.81	0.17	2.60	100%
5	CPI	1.00	91.00	0.20	1.67	6.13	100%
5	SBR	1.42	0.12	90.77	5.01	2.67	100%
5	EX	0.87	0.44	3.05	91.57	4.06	100%
5	OIL	1.46	0.41	2.35	8.31	87.47	100%

HORIZON		GDP	CPI	SBR	EX	OIL	TOTAL
30	GDP	93.47	2.52	0.93	0.18	2.91	100%
30	CPI	1.55	90.31	0.21	1.75	6.18	100%
30	SBR	1.50	0.15	90.64	5.01	2.70	100%
30	EX	0.91	0.48	3.06	91.46	4.10	100%
30	OIL	1.51	0.43	2.36	8.30	87.40	100%

HORIZON		GDP	CPI	SBR	EX	OIL	TOTAL
15	GDP	93.48	2.51	0.93	0.17	2.91	100%
15	CPI	1.54	90.32	0.21	1.75	6.18	100%
15	SBR	1.50	0.15	90.64	5.01	2.70	100%
15	EX	0.91	0.48	3.06	91.46	4.10	100%
15	OIL	1.51	0.43	2.36	8.30	87.40	100%

HORIZON		GDP	CPI	SBR	EX	OIL	TOTAL
50	GDP	93.47	2.52	0.93	0.18	2.91	100%
50	CPI	1.55	90.31	0.21	1.75	6.18	100%
50	SBR	1.50	0.15	90.64	5.01	2.70	100%
50	EX	0.91	0.48	3.06	91.46	4.10	100%
50	OIL	1.51	0.43	2.36	8.30	87.40	100%

Table 7: VDC result based on ARDL approach

The exogeneity based on VDC is stable across the set horizon. This shows the amount or percentage of dependence on its own past. For example, in horizon 30 (which is equivalent to 30 months after the sample period), GDP is the leading factor followed by CPI. The result for VDC is the same as ECM in our study. Hence, according to our findings, we can say:

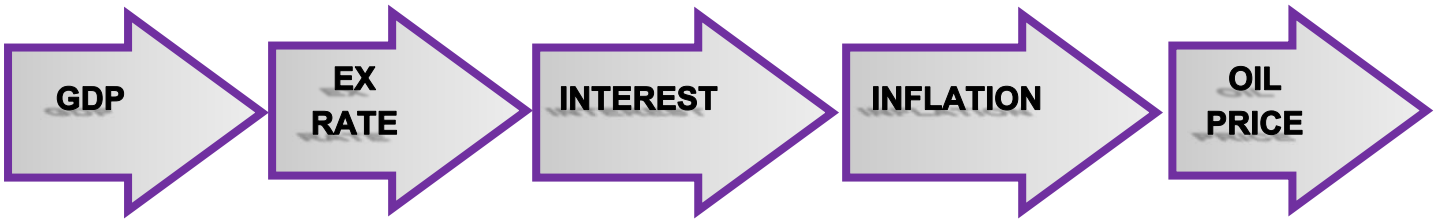

Figure 1: Granger causality from exogenous to endogenous

Interpretation:

- When GDP rises, this send signals to foreign investors that Singapore economy is doing well. This stems from the fact that GDP is used as an indicator on how well the economy is doing. Foreign investors will then invest in Singapore or buy products from Singapore. Which will increase the demand for Singapore dollars, thus a change in the exchange rate. Alternatively, when GDP rises, Singaporeans will have higher income, which will lead to high imports of foreign products. This will also change the exchange rate.
- When exchange rate changes, interest rate will also change. This can be explained by the previous theory where foreign investors will invest in Singapore. Interest rate can be affected by either: 1) foreign investors will invest in Singapore's T-bills, bonds and stocks which will influence the interest rate of Singapore. 2) The demand for loans from

the bank by the Singapore's companies will reduce, because they will receive funding from foreign investors. Mainly due to higher GDP or lower exchange rate.

- Relationship between interest rate and inflation. Recall that Singapore uses exchange rate monetary policy. Hence, there should not be a direct influence between interest rate and inflation. Hence, the factors that affect inflation are GDP, Exchange rate and also interest. Higher GDP will lead to higher income, thus higher spending and consumption, which will lead to higher inflation. Exchange rate can affect inflation based on the 'exchange rate monetary policy'. Interest rate can affect inflation by the change in 'cost of borrowing money'. When interest rate changes, Singaporean will borrow more money to buy commodities, which will lead to higher inflation rate.
- Finally, inflation can affect oil price. This is because when inflation rises, the cost of living will also rise. The oil-refining companies will have to spend more money to buy the raw materials or higher rental payment of the company. This will thus effect either the price of oil directly, or the supply of oil refined.

The Impulse response based on ARDL is showing the change in the variables in response to a shock in of the variable in the VAR. The graphical illustration is given in figure 2 below:

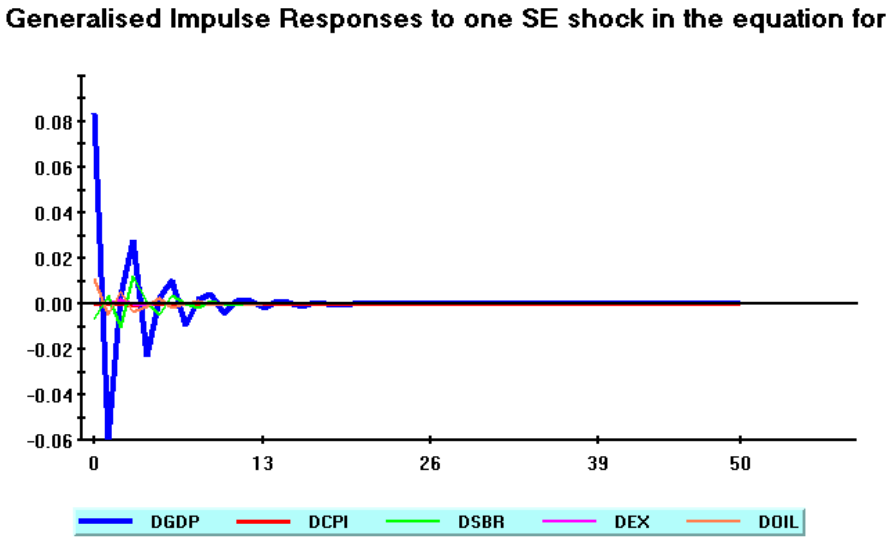

Figure 2: Generalised Impulse response when shocking one Variable.

As stated by previous literatures, the conventional time series cannot capture the effect of Oil price on GDP as it assumes linearity. Hence, we used NARDL method to see the impact of Oil on GDP, and vice versa. The result is shown in table 8.

Asymmetry statistics:

Exog. var.	Long-run effect [+] coef.	F-stat	P>F	Long-run effect [-] coef.	F-stat	P>F
loil	0.096	9.17	0.003	-0.002	.002922	0.957

	Long-run asymmetry F-stat	P>F	Short-run asymmetry F-stat	P>F
loil	212.2	0.000	6.91	0.009

Note: Long-run effect [-] refers to a permanent change in exog. var. by -1

Cointegration test statistics: t_BDM = -5.3069
F_PSS = 9.9500

Table 8: NARDL result for GDP as dependant, OIL as independent

Using the NARDL approach, we found that Oil has a significant effect on GDP as the F test is higher than the critical bound set by Pesaran et al. (2001). The F test of 9.9500 is higher than the upper bound for 99% significance of 6.36. Thus, our NARDL finding shows that oil price does affect GDP; which is consistent with our theory and literature.

Next, we look at the long run coefficient and the P value. Our result shows that GDP will increase by 0.96% when oil price increases, and this is significant at 5%. This can be explained by our theory that Singapore is an oil-refining country. Thus, an increase in oil price will increase the revenue of the oil-related business. The increase in this revenue will attribute to the total GDP. However, a reduction in oil price will reduce GDP by only a small and insignificant amount. This finding is consistent with the findings of Chang & Wong (2003). Hence, it can be said that the Singapore's policy of reducing oil intensity in Singapore since 1989 is effective.

Finally, we look at the significance level of the long run and short run symmetry. The null hypothesis is that it is symmetry. Based on our finding, it can be said that the relationship between oil and GDP is asymmetric, hence it is contradictory to our ARDL finding.

We next change the dependent variable and independent variable; to know whether GDP affects oil price. The result from table 9 shows that our F value is 3.0384 which is insignificant as is less than the critical bounds for 10% significance level (which are between 3.17 – 4.14). This is possible because Singapore is not an oil producing country. Singapore only import and export oil from other countries. Thus, a change in Singapore's GDP should not affect the global oil price. Recall that Singapore is a small and open economy. The changes in Singapore's GDP would not affect the global factor, but a change in global factors can affect Singapore's GDP.

Asymmetry statistics:

Exog. var.	Long-run effect [+] coef.	F-stat	P>F	Long-run effect [-] coef.	F-stat	P>F
lgdp	4.250	9.438	0.002	-4.552	8.782	0.003

	Long-run asymmetry F-stat	P>F	Short-run asymmetry F-stat	P>F
lgdp	3.787	0.053	2.756	0.098

Note: Long-run effect [-] refers to a permanent change in exog. var. by -1

Cointegration test statistics: t_BDM = -2.9978
F_PSS = 3.0384

Table 9: NARDL result for OIL as dependant, GDP as independent

To show the graphical of our result in ARDL, we use the cumulative dynamic multipliers in NARDL. The following figure 3 shows the impact of GDP when Oil is set as an independent variable.

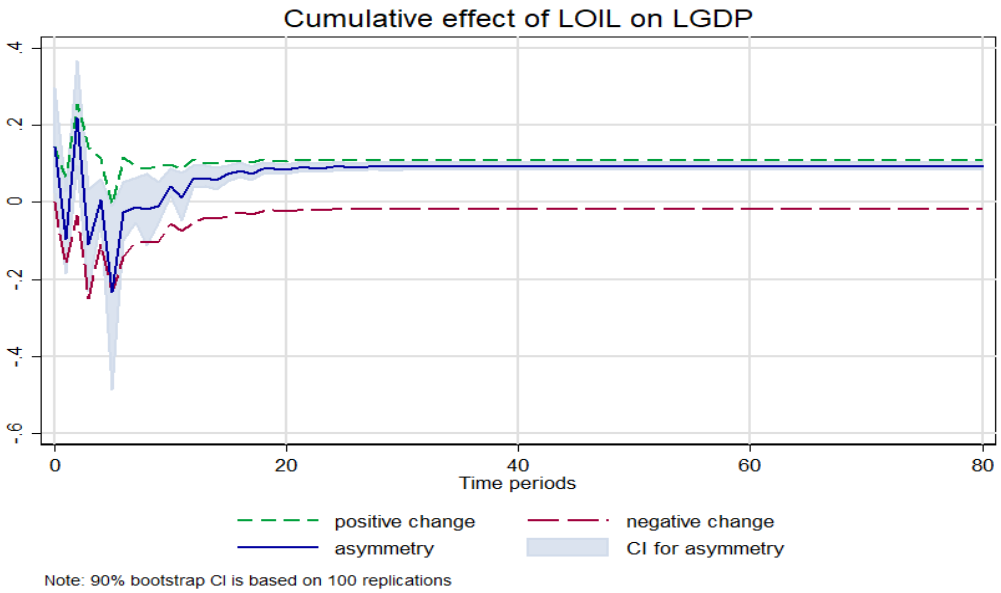

Figure 3: Cummulative dynamic multipliers when GDP is dependent and OIL is independent

Figure 3 shows an interesting story as the impact of oil on GDP is not straightforward. A positive change in oil will have both negative and positive impact on GDP. This is the result is consistent with the direct and indirect impact of oil as stated by Abeysinghe (2001). When oil price increase, the GDP of Singapore will initially increase due to higher exports to net oil exporter countries (as they have higher income). It will decrease when net oil exporter countries 'feel the pain' of an increase in oil price.

From another perspective, since Singapore is big in oil-related trading and businesses, oil-refining companies in Singapore can sell the refined oil at a higher price, thus higher revenue and higher GDP. Meanwhile, the non-oil related Singapore businesses will have a negative impact on GDP.

Another way to explain this is by the ripple effects of changes in oil price to other important sectors in Singapore. The relationship between oil price and tourism is well documented and can be derived logically. Amongst the literatures that examined the relationship between tourism and oil price are Chatziantoniou & et., (2013), Beckens (2008, 2011). We posit that is tourism will be affected as higher oil price will lead to higher cost of transportation. This is important as Singapore emphasize greatly on their tourism sector; like Universal studio of Singapore and the upcoming $1.7 billion futuristic glass airport (which have high facilities like swimming pool, indoor forest and world's tallest indoor waterfall) which will be open in 2019. Hence, one of the possible channels of how oil price affects GDP is through tourism. For example, Katircioğlu (2011) shows that there is a long-run equilibrium between tourism and GDP in Singapore. Katircioğlu (2011) also found that tourism is the leader while growth is the lager. In contrast, Lee (2008) found that there is no cointegration among GDP and tourism, and the granger causality test shows that growth is the one leading the tourism. To solve this, we examined the cointegration between tourism and GDP using the ARDL approach. Based on the ECM of ARDL, we found that tourism lead growth. Unfortunately, we found the cointegration based on ARDL to be inconclusive and thus unable to provide any additional conclusive information. The result will be shown in the appendix 2.

Concluding remarks and policy implications:

Singapore is a small and open economy but is highly engaged in oil-related business. This study test whether the volatility of oil price would affect the GDP of Singapore. We used ARDL and NARDL to test our hypothesis and found contradicting results. Based on ARDL, GDP will affect oil price through exchange rate, interest rate and inflation. However, using the NARDL approach, we found that Oil is the one that affects GDP of Singapore. A positive change in oil

price will increase GDP positively also, this is due to multiple factors such as the high engagement in oil-trading business. Upon closer inspection on the graph, we found that a positive change in oil price, will actually have both positive and negative change in GDP. One of the possible channels is through the tourism sector. We found that tourism leads GDP, however, our cointegration result for tourism-GDP is inconclusive thus unable to provide additional information.

We also found that Singapore's GDP is unaffected by a negative change in oil price (insignificant). However, a closer look at the graph shows that there is both positive and negative change (although insignificant).

Firstly, policy makers should be careful when deciding the 'effect of oil price'. This is because each method will have different result. Also, it should be noted that there is no straight-cut answer for a changed in the economic variables. This is because there are a lot of additional non-economic sectors which may have an impact on GDP. Finally, it is important to note that all economic variables may affect each other. In this particular study, we found theoretical reasoning for both of our ARDL and NARDL, despite that they have an opposite relationship result.

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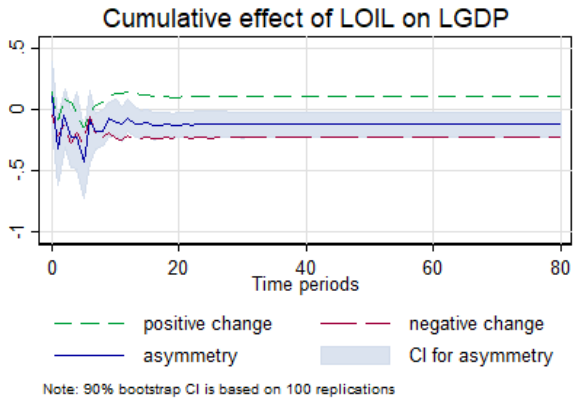
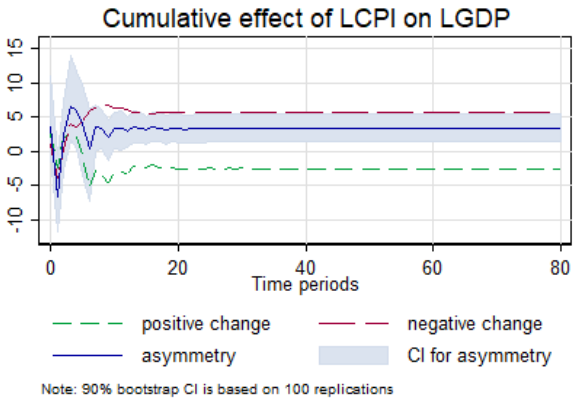
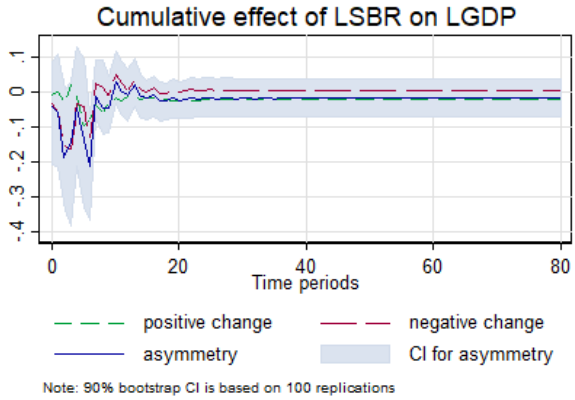
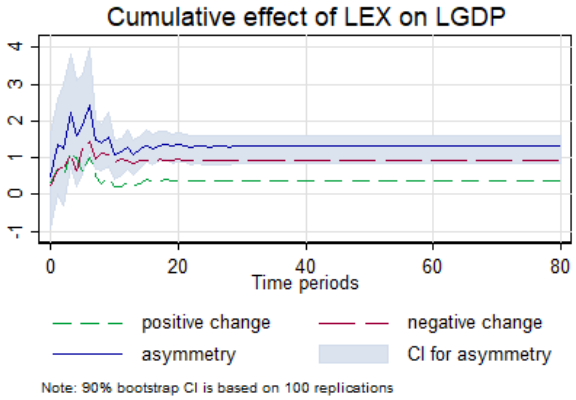
Appendix 1a

NARDL cumulative effect of all the variables on the dependent variable, GDP



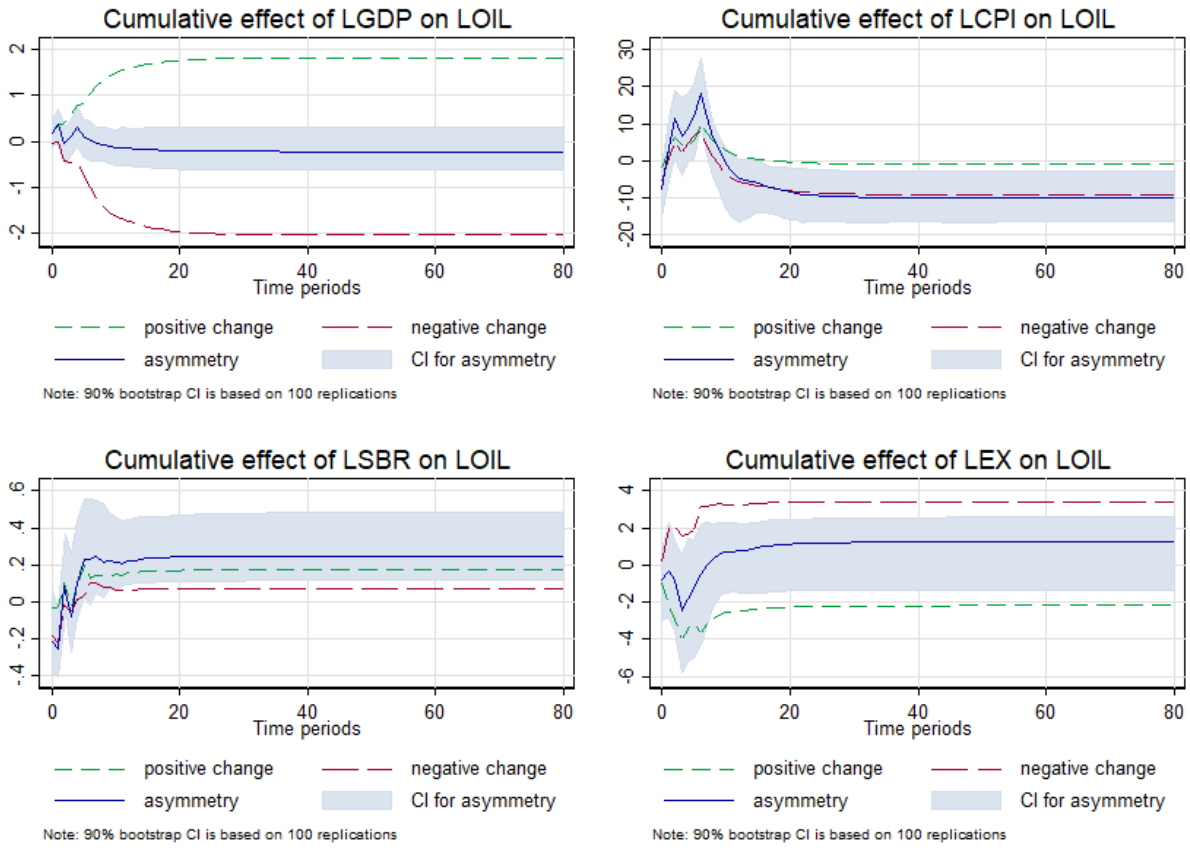






Appendix 1b

NARDL cumulative effect of all the variables on the dependent variable, Oil



Appendix 2

ARDL result for GDP, tourism and real effective exchange rate (we follow the methodology used by Belloumi, M. (2010).)

VARIABLE	*SHORT TERM*	*LONG TERM OR "ERROR TERM"*	*F-VALUE*	*RESULT*
DGDP	DGDP INPT DGDP{1-4} DREER{1-4} DTOUR{1-4}	LGDP(-1) LREER(-1) LTOUR (-1)	4.2954	INCONCLUSIVE AT 10%
DREER	DTOUR INPT DGDP{1-4} DREER{1-4} DTOUR{1-4}	LGDP(-1) LREER(-1) LTOUR (-1)	2.2985	EXO
DTOUR	DREER INPT DGDP{1-4} DREER{1-4} DTOUR{1-4}	LGDP(-1) LREER(-1) LTOUR (-1)	1.734	EXO

THREE VARIABLE	90%		95%		97.50%		99%	
	LOWER	**UPPER**	**LOWER**	**UPPER**	**LOWER**	**UPPER**	**LOWER**	**UPPER**
	3.484	**4.458**	**4.066**	**5.119**	**4.606**	**5.747**	**5.315**	**6.414**

GDP is inconclusive at 90% as it is between lower and upper bound of 3.484 and 4.458.

Result from ECM based on ARDL

HORIZON		GDP	REER	TOUR	TOTAL		Ranking
5	GDP	63.00	16.32	20.68	1.00		2
5	REER	37.02	48.39	14.59	1.00		3
5	TOUR	23.44	12.91	63.65	1.00		1
HORIZON		GDP	REER	TOUR	TOTAL		Ranking
10	GDP	62.99	16.32	20.68	1.00		2
10	REER	37.03	48.39	14.59	1.00		3
10	TOUR	23.45	12.92	63.64	1.00		1
HORIZON		GDP	REER	TOUR	TOTAL		Ranking
30	GDP	62.99	16.32	20.68	1.00		2
30	REER	37.03	48.39	14.59	1.00		3
30	TOUR	23.45	12.92	63.64	1.00		1