Oil Price Dynamics and Currency-Hedging Behavior

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February 2020

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Abstract

For Korea, a major crude oil importer, we document that after crude oil prices spike, cross-currency basis swap spreads tend to tighten as the propensity to currency-hedge rises.

Keywords: Oil prices, currency hedging, cross-currency swaps, dollar-won cross-currency basis swap spreads, oil importer

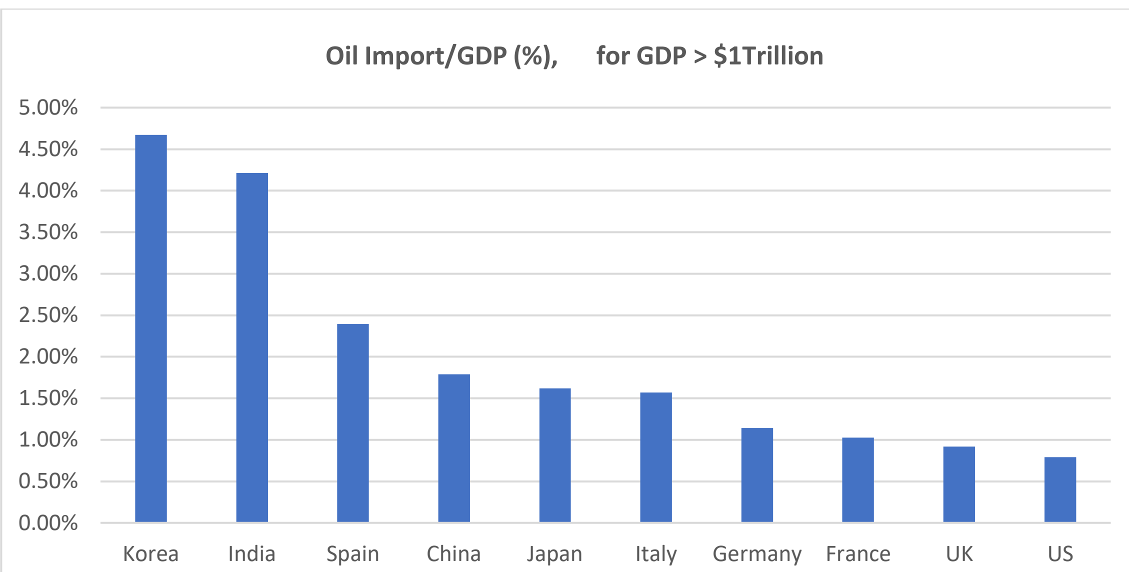
JEL: F31, G15, Q41, Q43

1. Introduction

When oil prices increase, how does the cross-currency basis swap spread of an oil-importing country change? This paper investigates how changes in oil prices influence currency-hedging behavior in Korea, one of the world's largest oil importers. We document that the currency-hedging practice of buying US dollars forward in the dollar-won currency swap markets, which leads to a tighter cross-currency basis, is stronger and more significant during periods of elevated oil prices but is considerably weak or even nonexistent when oil prices are depressed.

Why Korea? We focus on South Korea for several reasons. As one of the growing industrialized economies, Korea is a major oil importer. According to the Observatory of Economic Complexity (OEC), crude oil constitutes the biggest portion of Korea's imports. In 2018, Korea's oil import to GDP was near 5%, the highest relative to peers (see Fig.0). Thus, movements in oil prices should affect Korea and potentially trigger preemptive responses – such as currency-hedging – to mitigate adverse effects of variations in oil prices. As oil prices are quoted in US dollars, a persistent increase would elevate the cost of oil imports, especially if the exchange rates of the oil importing countries weaken relative to the US dollar. Beckmann & Czudaj (2013) show that elevated oil prices often go with currency depreciation for major oil-importing countries.

Fig 0: Oil imports/GDP of large oil importing countries



Source: Bloomberg

Bouri (2015) and Wang et al. (2013) note that fluctuations in commodity prices, particularly oil prices, severely affect asset prices and macroeconomic outcomes of importing nations. Shin, Baek & Heo (2018) argue that, as an oil importing nation, Korea's imported crude oil demand is more responsive to oil price spikes than plunges, which means that a rise in oil prices should make oil importers to protect themselves, one of which could be an increased participation in currency hedging. Yet, the question of how movements in oil prices relate to changes in the dollar-won basis, which is of interest in risk management both in the fixed income and commodities markets, is less understood. This paper fills that gap in the literature.

We use Markov switching and threshold models together with standard impulse response techniques to empirically resolve the important question of determining whether there is evidence that Korean oil importers engage in more hedging activity in the currency swap market when oil prices are high. This enables us to explore whether an increase in oil prices enlarge currency-hedging to the extent that it tightens the dollar-won basis. By examining the effect of changes in oil prices on the dollar-won cross-currency basis swap spreads, we document that changes in dollar-won basis and oil prices are dynamically related and oil-price regime dependent. We show that a rise in oil prices does not necessarily induce currency hedging that tightens the dollar-won basis, which implies that just about any rise in crude oil prices may not go together with tighter dollar-won basis. Instead, we find evidence that an increase in oil prices is associated with tighter dollar-won basis only when oil prices are in a high regime, implying that currency-hedging occurs mostly when oil prices have exceeded certain threshold levels which we estimate to have a median of around $55. It is at this value that the dollar-won basis tightens in response to additional increases in oil prices. However, when oil prices are in a low regime, such as during periods when oil prices collapse, we find no evidence that tighter dollar-won basis is associated with increases in oil prices. Our results suggest that the desire to hedge against adverse exchange rate movements is low when oil prices are sufficiently low (that is, below $55), but high when oil prices are high. Thus, hedging behavior in the swap market is not uniform across all oil price regimes. While it is active during regimes of high oil prices, it is more tranquil when oil prices are in low regimes.

In terms of the literature, while there are studies showing that Korea's heavy oil importers engage in currency hedging (Yun & Kim, 2010), not much is known about how the oil-basis relationship and how it has evolved over time. Previous studies on the consequences of changes in oil prices have focused mainly on macroeconomic variables such as unemployment and inflation, other commodities market such as gold (see Zhang & Wei (2010)), exchange rates [see Hurn, Phillips & Shi (2016), Gomez-Gonzalez, Hirs-Garzon & Uribe (2019), Chuliá, Fernández & Uribe (2018), Baruník, Kočenda & Vácha (2017)] and financial markets (see Zhang (2017), Wang & Liu, 2016; Khalfaoui, Boutahar & Boubaker, 2015; Lee, Abood, Ghazoul, Barus, Obidzinski & Koh, 2014; Lin, Wesseh & Appiah, 2014; Hamilton, 2003). Instead, in this paper, we focus on a new question to investigate the links between oil prices and cross-currency basis.

To provide some intuition that motivates our study of the relation between changes in oil prices and the dollar-won cross-currency basis, Fig. 1a below provides a 20-month rolling correlation between changes in oil prices and dollar-won basis.

Figure 1a: Rolling correlation of changes in 1-year dollar-won (KRWUSD) basis and oil prices

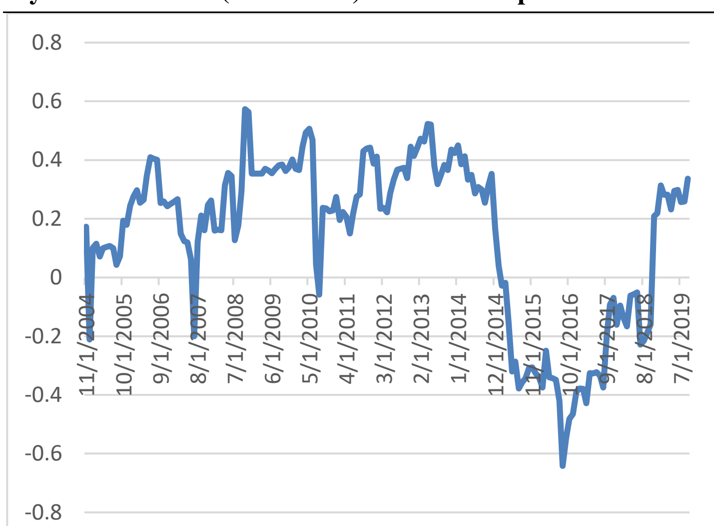
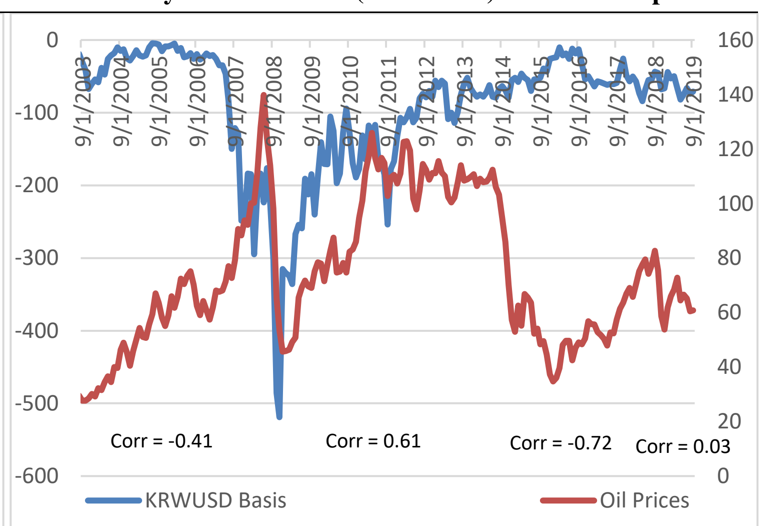


Figure 1b: Evolution of the historical time series of 1-year dollar-won (KRWUSD) basis and oil prices



Source: Bloomberg, author computations. Dollar-won cross-currency basis swap spread is in basis points, monthly data

As the graphs show, there is a negative relation between changes in oil prices and dollar-won basis in periods of low oil prices whereas the relation turns positive otherwise. The negative association implies that an increase in oil prices goes together with wider dollar-won basis, which suggests that in periods with negative association, oil importers do not hedge against adverse movements in exchange rates as oil prices are already depressed. On the other hand, the positive association between changes in oil prices and the dollar-won basis in periods of elevated oil prices suggests that additional increases in oil prices is associated with tighter dollar-won basis. This implies that in periods with high oil prices, hedging against adverse exchange rate movements is more common.

This preliminary evidence reveals two regimes or threshold effects between changes in oil prices and the dollar-won basis: One regime in which changes in oil prices and dollar-won basis are positively related when oil prices are high, and another where they are negatively related or unrelated when oil prices are depressed. This leads us to consider a Markov switching model with 2 regimes – a high oil price regime corresponding to a positive dollar-basis relation and a low oil price regime which corresponds to a negative oil-basis relation and an inactive currency hedging. We also estimate a threshold model which helps us to quantify the regimes by determining the level of oil prices after which the relation between changes in oil prices and dollar-won basis switches.

The rest of this paper is organized as follows. Section 2 describes the data on dollar-won basis and oil prices. Section 3 presents results of the standard impulse response functions. We also present a robustness exercise to show that our findings generally hold strong. Section 4 concludes.

2. Data and Methodology

2a. Data Description

To examine the effects of fluctuations in oil prices on the cross-currency basis swap spreads for Korea, this paper uses monthly[1] data gathered from Bloomberg. The data samples consist of observations from February 2003 to September 2019 of dollar-won cross-currency basis swap spreads at the active 1-year maturity, movements of which capture hedging behavior in the swap market, Brent crude oil prices and other control variables such as exchange rates, sovereign credit default swaps and Libor-OIS spreads to control for the effects of dollar exchange rate pass-through, risk of sovereign default, and dollar funding pressure respectively. As our data samples range from 2003 to 2019, the study covers periods of depressed and elevated oil prices that have been observed in nearly two decades.

2b. Methodology

We employ Markov switching and threshold regression models. The Markov switching model considers the effects of the possibility of different oil price regimes and examines the relations between fluctuations in oil prices and changes in the dollar-won basis in these regimes. The threshold regression model is then used to determine or quantify appropriate range of oil price values that make up each regime. It does this by estimating the threshold level, wherever it exists and is significant, that separates the range of values of oil prices into high and low oil price regimes. It can also be viewed as a robustness check for the Markov switching model as it estimates the relations between changes in oil prices and dollar-won basis in the partitioned subsamples. We also implement a VAR model to explain the evolution of the response of dollar-won basis to oil price shocks in the impulse-response sense.

As a preliminary procedure, we first run a battery of tests for non-stationarity. Results obtained, not presented but available on request, show that the variables in levels are not stationary but become stationary after first differencing. To avoid issues of misspecification, it is the first-differenced variables, which are stationarized, that enter all models used for our analysis.

To concretize how each model is applied, we sketch a Markov switching model and following this, we also present a threshold model. Both models are reported in the appendix.

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[1] Some arguments for monthly data and against other data sampling such as daily data are documented in existing studies including Bailey and Stulz (1990), Smith et al. (1993), Sharma (2007) and Charoenwong and Feng (2017). Some of these studies find that daily data suffer a great deal from unwanted noise content while others argue that such data are more susceptible to residual mean misspecification. We look to lessen the disadvantages of unwanted noise in our analysis as the noise can play a big role to blur the signal of relationships we seek and make it cumbersome to separate the signal from noise. At monthly data series, the noise content dies away, and monthly data series is ideal as it smooths out unnecessary volatility from excessive noise and makes signals more tractable. Monthly data also eases modelling, easier to identify changes in trends in relationships, and better for strategic long-range analysis such as the long-term oil contracts that importers often embark upon.

3. Empirical results

To implement the empirical analysis, we estimate the Markov switching and threshold models motivated above. We first estimate the Markov switching model. Subsequently, we perform a sample splitting analysis using a dummy variable which we then finally formalize in a threshold model setting. Below, we present the results of Markov switching model for our data[2]. Following this, we display the observational dummy variable analysis results and then the results from the threshold analysis.

Table 1a: Markov switching results of changes in oil prices on fluctuations in the dollar-won basis

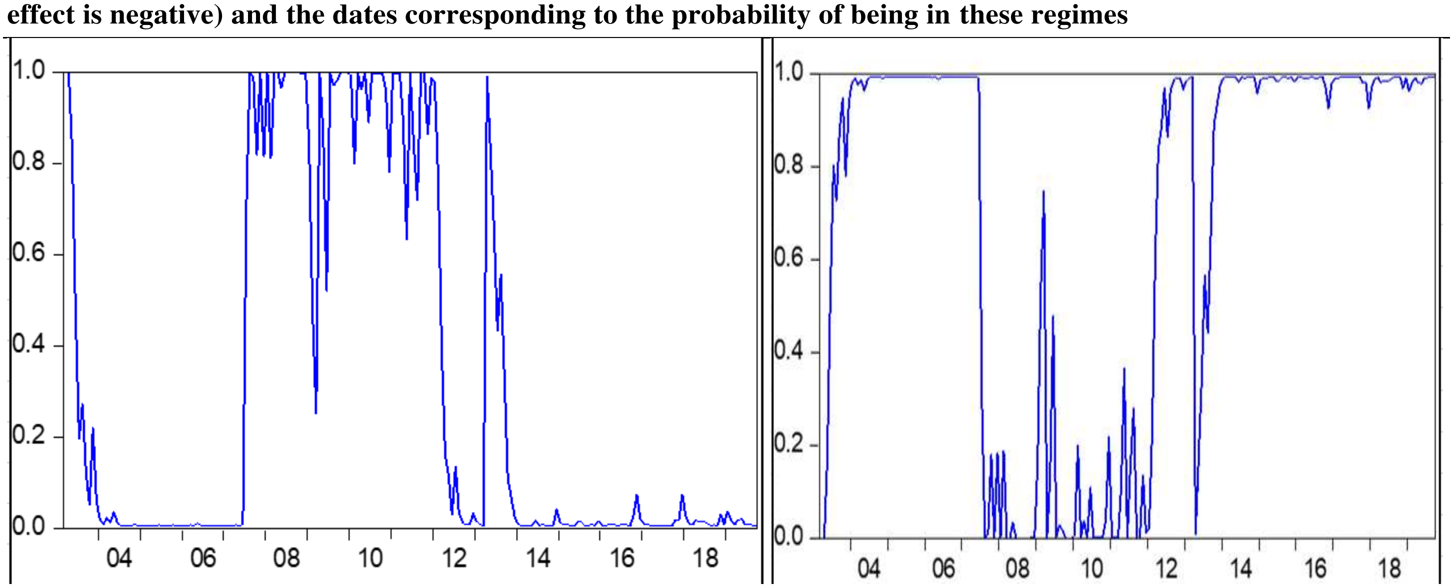
	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2	Regime 1	Regime 2
Oil	2.510***	0.110	2.130***	-0.030	-0.120	1.30*	1.080	-0.117
	(0.870)	(0.190)	(0.810)	(0.180)	(0.180)	(0.79)	(0.730)	(0.186)
Exchange rate			-0.150***	-0.150***	-0.104***	-0.104***	-0.100***	-0.100***
			(0.040)	(0.040)	(0.039)	(0.039)	(0.040)	(0.040)
CDS					-0.378***	-0.378***	-0. 385***	-0.385***
					(0.102)	(0.102)	(0.101)	(0.101)
Libor – OIS							-0.424***	-0.424***
							(0.163)	(0.163)
Constant	-3.19	0.74	-2.5	0.55	0.09	-1.55	-1.31	0.05
	(7.34)	(0.96)	(6.77)	(0.93)	(0.93)	(6.36)	(5.82)	(0.94)
Sigma	4.01	2.38	3.93	2.35	2.34	3.86	3.77	2.35
	(0.09)	(0.07)	(0.10)	(0.06)	(0.06)	(0.09)	(0.09)	(0.07)

Note: Changes in oil prices (Oil) is the regime dependent regressor; *, **, *** means significance at 10%, 5%, 1% levels. Standard error in parenthesis

Table 1b: Transition probabilities between states (regimes) and expected duration per state

	Transition probabilities		Expected durations (months)	
	State 1	State 2	State 1	State 2
State 1	0.96	0.04	23.80	49.35
State 2	0.02	0.98		

Figure 2: Probability to be in each regime (one regime where oil prices exert positive basis effect & another where effect is negative) and the dates corresponding to the probability of being in these regimes



Note: The regime of positive oil-basis relations corresponds to periods of active currency-hedging; that is, when generally high levels of oil prices lead to a rise in currency hedging that tightens the basis from a positive oil price change. Whereas a negative oil-basis relation matches with inactive currency-hedging, i.e. when oil prices are so depressed that they do not trigger the type of active currency hedging that tightens the basis from a positive oil price change. In the first graph (on the left), the probability of being in a state corresponding to the period 2008 to around 2013 is the greatest while the probability of being in a state corresponding to the period from 2014 is the least. The second graph (on the right), however, is a mirror image of the first graph. It reverses outcomes from the first graph and reveals that the period from 2014 now corresponds to the highest probability whereas earlier periods, particularly between 2008 to 2013, has the least probability. Thus, the first graph represents a state that characterizes high oil prices while the second graph displays a state of low oil prices. In a high oil price regime, the probability of being in a low oil price state is low. This explains why the probability is very high during historic periods of high oil prices and low in periods of depressed oil prices. Conversely, in a low oil price state, the probability of being in a high oil price state is low, which is why the probability is very high during historic periods of low oil prices and low in periods of high oil prices. This result is robust: we also control for other variables that have been found to influence the dollar-won basis and find that our results, particularly the behavior of the probabilities, are largely robust.

The results displayed above are those from the Markov switching regression model. As the results show, the relations between changes in oil prices and dollar-won basis is in general not the same in any two regimes. In one regime, there is evidence that a rise in oil prices induces tighter dollar-won basis, which implies active currency hedging in the swap market. This is the high oil price regime. In the other regime, there is either a negative or insignificant relation between changes in oil prices and dollar-won basis, suggesting there is no evidence of active currency hedging in the swap market. This is the low oil price regime. The Markov switching specification therefore supports the existence of two regimes: one where there is active hedging in the currency swap market and another where hedging is inactive. Thus, the response of the basis to changes in oil prices are generally different in both regimes. One reason for the generally different outcomes in the two regimes could be explained by the partial hedging sometimes employed by Korean entities (Hahm, Shin & Shin, 2014). Importers of oil in Korea have an incentive to hedge in an environment of elevated oil prices whereas exporters of refined and other products have little or no incentive to hedge. This imbalance puts a net upward pressure on the dollar-won basis, making it to tighten when oil prices increase in a high regime. Conversely, in a low oil price regime, Korean exporters of refined and other products, especially those whose costs are majorly in the won, are more motivated to hedge when export revenues in dollars shrink while oil importers have little or no incentive to hedge. Thus, the basis widens even when oil prices increase in a low regime.

The transition probability matrix and expected durations are displayed in Table 1b. Looking at the transition probabilities, there appears to be considerable state-dependence, with a high probability of remaining in the regime of origin. For the two states or regimes, the probabilities of remaining in the same state are significantly high and dominate the probability of moving to a new state. For instance, the probabilities of remaining in state 1 and state 2 - if the system is most recently in the same state - are 0.96 and 0.98 respectively, strictly dominating the probabilities of moving to a new state. In addition, the expected duration to be in a state before a brief movement to another state is 24 for state 1 and 49 for state 2.

Finally, as shown in the first graph in Fig. 2, the probability of being in a state is persistently high in the periods from 2008 to 2013 and lowest from around 2014. The periods of low probability correspond to historic periods of depressed oil prices while the period of high probability corresponds to historic periods of elevated oil prices. This state thus depicts the high oil price regime. Conversely, in the second graph, historic periods of low oil prices have the highest probability of being in that state while periods of low probability correspond to historic periods of elevated oil prices. This suggests that the state depicts a low oil price regime. Overall, the predicted probabilities of being in low and high states of oil prices coincide quite nicely with historic periods of elevated and depressed levels of oil prices.

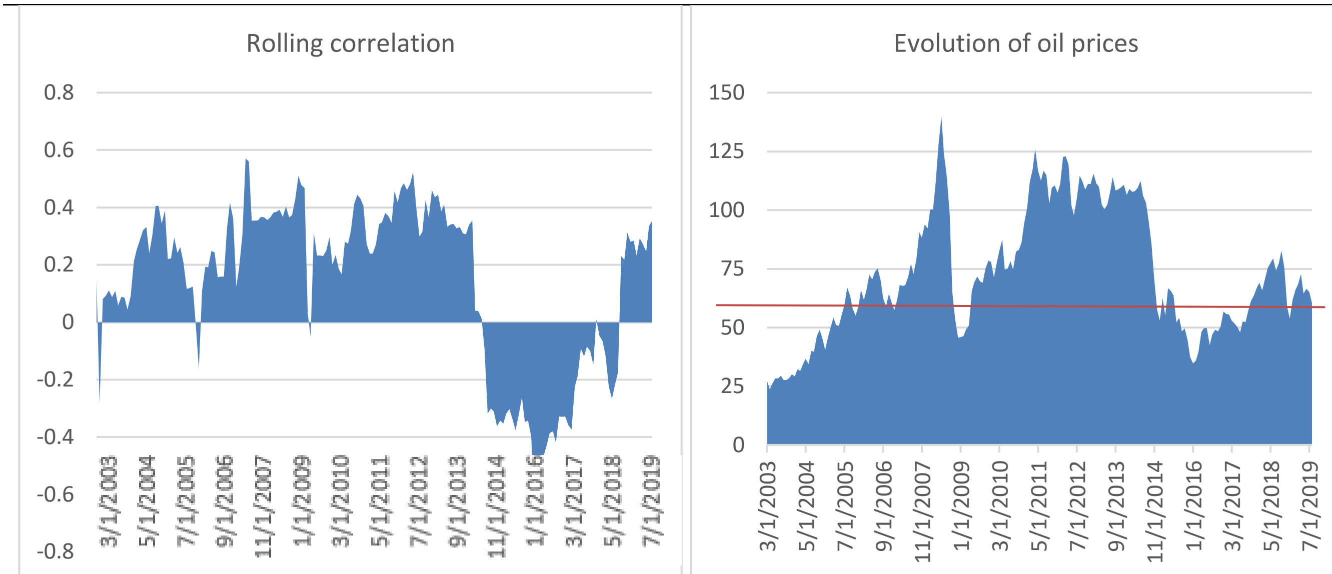
4. Classifying high and low regimes by observation and using formal threshold models

So far, we have demonstrated the existence of two regimes or states of the levels of oil prices in which the effect of changes in oil prices on the currency hedging behavior using Dollar-won basis can be distinct. In this section, we attempt to empirically quantify what constitutes high and low regimes or states of oil price levels. We begin by choosing a predetermined threshold value, based on observations from the data, which we use to split the data samples into high and low oil price regimes. Following this, we formalize the analysis by using the previously exposited threshold model to econometrically estimate, rather than impose, the appropriate threshold levels of oil prices which split the data into the regimes of high and low oil prices.

4.1 Regime characterization by observation and using dummy variables

Fig. 3 below redisplays the rolling correlation between changes in oil prices and dollar-won basis together with the evolution of oil prices in the international commodities market. As previously revealed, the link between changes in oil prices and Dollar-won basis appears to be segmented into two regimes where, on the one hand, the link is positive and, on the other hand, the link is negative.

Figure 3: Rolling correlation of changes in oil prices and dollar-won basis (LHS); oil prices (RHS)



By and large, by observing both graphs, we see that periods of elevated oil price levels, mostly beyond \$55, coincide with a positive link between changes in oil prices and dollar-won basis, whereas periods of low levels of oil prices, beneath the \$55 mark, show a weak or negative link between changes in oil prices and dollar-won basis. Accordingly, we set a threshold level of around \$55. When oil prices exceed this value, we are in the high regime of oil prices. In this regime, the link between changes in oil prices and dollar-won basis should be positive. On the other hand, when oil prices are below this level, we are in the regime of low oil prices and the link between changes in oil prices and dollar-won basis should be weak or negative. To examine the validity of this observation, we run a standard regression model wherein we introduce a dummy variable together with the interaction between the dummy variable and changes in oil prices. This is aimed at investigating the observed links between changes in oil prices and Dollar-won basis in the different regimes identified for oil prices.

Our dummy variable takes a value of 1 when oil prices are in the proposed high regime (above \$55), while it takes a value of 0 for oil prices in the low regime (below \$55). The baseline regression can thus be specified as:

$$Y_t = \beta_0 + \beta_1 X_t + \beta_2 D_t + \beta_3 (X_t \times D_t) + \epsilon_t \qquad (1)$$

where X_t and Y_t represent changes in oil prices and Dollar-won basis,

$$D_t = \begin{cases} 1 & if\ oil\ prices > \$55 \\ 0 & if\ oil\ prices \leq \$55 \end{cases}$$

and

$$\frac{\partial Y_t}{\partial X_t} = \beta_1 + \beta_3 D_t$$

Note that, in this specification, β_1 represents the link between changes in oil prices and dollar-won basis when oil prices are in the low regime, i.e. below \$55; it does not measure the overall main effect. β_3 is the differential effect of changes in oil prices on Dollar-won basis when oil prices are in the high regime, i.e. more than \$55, over when they are in the low regime. Meanwhile, β_2 is the coefficient of the dummy variable and ϵ_t is the standard idiosyncratic effort term. The results are displayed in the table below.

Table 2: Effect of changes in oil prices on the basis: the role of prevailing levels of oil prices

	dollar-won (KRWUSD) basis
$\boldsymbol{Oil}$	-1.19
	(1.01)
$\boldsymbol{Dummy}$	-6.99
	(4.99)
$\boldsymbol{Oil \times Dummy}$	2.96***
	(1.07)
$\boldsymbol{Constant}$	4.41
	(4.20)
$\boldsymbol{R^2}$	0.11
$\boldsymbol{N}$	199

*, **, *** significant at 10%, 5% and 1%. Standard error in parenthesis. The dummy variable takes a value of 1 when oil prices are above $55 and 0 when they are below. The $55 is imposed by inspection. This will be put to a more stringent verification test using formal threshold regression models.

As shown in Table 2, the coefficient on the interaction term $(\boldsymbol{Oil \times Dummy})$ turns out convincingly positive and significant for the basis. Each regression uses a basis at a different maturity which helps to provide additional source of robustness. Column (1) uses the 1-year basis while column (2) is based on the 5-year basis. The main result is that the interaction term, which shows how changes in oil prices may influence dollar-won basis is positive. Moreover, the interaction term for the 1-year basis is much more significant, at the 1% level, and provides support for the finding that changes in oil prices have a stronger positive impact on the 1-year than 5-year basis when oil prices are in the high regime.

On the other hand, the dummy variable, which indicates the prevailing regime of oil prices, is itself insignificant and sometimes even changes sign whereas the sign of the interaction term holds firm. This could in part be due to the interaction term capturing an important hedging decision taken when prevailing levels of oil prices have attained a certain state — that is, reaching certain levels of oil prices may be a trigger for subsequent hedging decisions, and is not the decision in and of itself. Remarkably, the coefficient on changes in oil prices, which in our specification measures the link between changes in oil prices and dollar-won basis in the low oil price regime, turns out negative and displays considerable variation in significance even when the positive relation between changes in oil prices and dollar-won basis continues to hold—clearly making it vital to look at the links between changes in oil prices and dollar-won basis at different states of oil prices.

Overall, the results confirm that depressed levels of oil prices can lessen the need to engage in currency hedging in the currency swap market, which explains the negative or insignificant links documented between changes in oil prices and Dollar-won basis. Meanwhile, elevated levels of oil prices can act as a trigger for significant currency hedging in the swap market, which potentially explains the strong and positive relation observed between changes in oil prices and dollar-won basis during periods of elevated oil price levels. Thus, we argue that oil prices beyond $55 can act as a trigger for agents to hedge in the swap market. Our findings reinforce the view that the effects of changes in oil prices on the basis would depend in some ways on the prevailing state or regime of oil prices, consistent with the results we earlier obtained.

4.1.1 Inclusion of additional controls

In the literature, the strong negative effect of fluctuations in dollar exchange rates and sovereign credit default swaps (CDS) on changes in cross-currency basis swaps is well known. It is one of the few consistent results to have emerged in studies on the persistent deviations from covered interest parity. In this light, one could argue that the reason changes in oil prices appears significant in our analysis is because changes in exchange rates and sovereign CDS have not been controlled for. Thus, for further robustness checks, we sequentially add changes in oil prices followed by changes in CDS to the list of predictors in our baseline regression. We report our results in Table 3.

Table 3: Effect of changes in oil prices on the basis – robustness checks based on the dummy variable regression

	dollar-won (KRWUSD) basis	dollar-won (KRWUSD) basis
$\boldsymbol{Oil}$	-1.35	-1.79**
	(0.88)	(0.84)
$\boldsymbol{Dummy}$	-4.47	-4.21
	(4.39)	(4.16)
$\boldsymbol{Oil \times Dummy}$	2.01**	2.33***
	(0.95)	(0.91)
$\boldsymbol{Exchange\ rate}$	-0.66***	-0.28***
	(0.09)	(0.06)
$\boldsymbol{CDS}$	--	-0.43***
	--	(0.09)
$\boldsymbol{Constant}$	2.60	2.50
	(3.70)	(3.50)
$\boldsymbol{R^2}$	0.32	0.39
$\boldsymbol{N}$	199	199

*, **, *** significant at 10%, 5% and 1%. Standard error in parenthesis. The dummy variable takes a value of 1 when oil prices are above $55 and 0 when they are below. The $55 is imposed by inspection. This will be put to a more stringent verification test using formal threshold regression models.

Interestingly, including both variables leads to a couple of reinforcing results. First, the interaction term remains strongly positive and significant, particularly for the basis. Second, the coefficient on changes in oil prices, that is the non-interaction term, remains negative, though still not always statistically significant. This implies that there is no evidence that changes in Dollar-won basis are strongly linked with changes in oil prices when oil prices are in the low regime – suggesting that hedging against adverse currency movement when oil prices are in a depressed state is unpopular. As expected, changes in exchange rates and CDS enter significantly and negatively in most of regressions. The interaction between changes in oil prices and the dummy variable, representing the prevailing state of oil prices, remains robust.

As a final robustness check, we also included changes in Libor – OIS spread to capture direct dollar funding pressure in the dollar cash market. This variable is among the few consistently significant determinants of changes in the cross-currency basis over time across countries. The results are displayed in Table 4 below.

Table 4: Effect of changes in oil prices on the basis – further robustness checks based on the dummy variable regression

	dollar-won (KRWUSD) basis	dollar-won (KRWUSD) basis	dollar-won (KRWUSD) basis
$\boldsymbol{Oil}$	-1.35	-1.79**	-1.07
	(0.88)	(0.84)	(0.82)
$\boldsymbol{Dummy}$	-4.47	-4.21	-2.49
	(4.39)	(4.16)	(3.98)
$\boldsymbol{Oil \times Dummy}$	2.01**	2.33***	1.47*
	(0.95)	(0.91)	(0.88)
$\boldsymbol{Exchange\ rate}$	-0.66***	-0.28***	-0.21***
	(0.09)	(0.06)	(0.06)
$\boldsymbol{CDS}$	--	-0.43***	-0.47***
	--	(0.09)	(0.09)
$\boldsymbol{Libor - OIS}$	--	--	-0.48***
			(0.10)
$\boldsymbol{Constant}$	2.60	2.50	1.36

	3.70	3.50	3.34
R^2	0.32	0.39	0.45
N	199	199	199

*, **, *** significant at 10%, 5% and 1%. Standard error in parenthesis. The dummy variable takes a value of 1 when oil prices are above $55 and 0 when they are below. The $55 is imposed by inspection. This will be put to a more stringent verification test using formal threshold regression models.

The results, reported in Table 4, show that previous findings remain unaltered. The results continue to support the finding that prevailing levels of oil prices provide additional insight into how changes in oil prices impact currency hedging decisions and hence movements in KRW cross-currency basis. Finally, a look at the results, especially for the basis, reveals that despite including changes in exchange rate as a control, changes in oil prices still have a positive and significant effect on changes in Dollar-won basis. This suggests that the effects of oil prices on Dollar-won basis are not only through variations in exchange rates. Indeed, the effects can emanate, for example, from the investing and hedging activities of large reserve banks or sovereign wealth funds of emerging markets that are major crude oil exporters and that experience a surge in investible US dollars during high oil price regimes.

4.2 Regime characterization using formal threshold models

In the preceding section, we identify by observation a potential threshold level of $55 for oil prices and use this threshold level to quantify and classify or characterize what qualifies as high and low oil price regimes. We then introduce a dummy variable to help in ascertaining how changes in oil prices and Dollar-won basis are related in the different regimes. In this section, we formalize this exercise by using the threshold regression model motivated in section 3. The model provides a more rigorous way, rather than mere observation or inspection, to econometrically determine the value of the appropriate threshold level, characterize the high and low regimes and examine how changes in oil prices and dollar-won basis are related in both regimes.

Our threshold specification includes lagged dependent variable, the purpose of which is to incorporate a partial adjustment for any mean reverting behavior in changes in the basis. The negative lagged dependent variable indicates a reversion towards an equilibrium position, consistent with the stationarity of changes in the basis which is the dependent variable. The lagged dependent variable also indirectly captures and controls for all variables that influenced changes in basis in the previous month but not explicitly included in the model. See Keele & Kelly (2006) for a persuasive exposition of several benefits of specifying lagged dependent variable as a regressor. As a robustness exercise, we also sequentially include previous control variables. We report our results in Table 5.

Table 5: Threshold analysis of oil price changes on dollar-won basis. Threshold variable is level of oil prices

	dollar-won (KRWUSD) basis	**dollar-won (KRWUSD) basis**	**dollar-won (KRWUSD) basis**	**dollar-won (KRWUSD) basis**
Lagged dollar-won basis	-0.10	-0.06	-0.10*	-0.09*
	(0.06)	(0.059)	(0.06)	(0.05)
Oil				
Low regime	-4.87***	-2.21***	-2.51***	-2.31***
	(1.60)	(0.88)	(0.92)	(0.88)
High regime	1.74***	1.12***	0.67**	0.58*
	(0.36)	(0.36)	(0.34)	(0.32)
Threshold estimate	46.73***	55.57***	53.49*	53.49*
F-statistic for threshold	16.33	13.06	10.44	7.78
Bootstrap p-value for threshold	0.01	0.01	0.05	0.10
Controls				
Exchange rate		-0.39***	-0.24***	-0.18***
		(0.05)	(0.06)	(0.05)
CDS			-0.45***	-0.46***
			(0.09)	(0.09)

LIBOR-OIS				-0.49***
				(0.10)
Samples in high regime	169	139	139	w
Samples in Low regime	29	59	60	m
R^2	0.14	0.32	0.40	0.47

*, **, *** significant at 10%, 5% and 1%. Standard error in parenthesis. Threshold variable is oil price level. Estimated threshold values (threshold estimate) are displayed. High regime corresponds to the sample partition for which oil prices are above the threshold estimate, otherwise it is low regime. The estimated threshold value of the level of oil prices ranges from $47 to $56 with a median of around $55.

Interestingly, as shown in Column 2, the estimated threshold value of the level of oil prices is around $55; this is largely in agreement with the threshold level imposed by observation, providing some support for the threshold level obtained by observation. We also find that the estimated threshold level of oil prices is statistically significant. The level of oil prices acts as sample-splitting (or threshold) variable which separates the samples into the high and low oil price regimes. This allows for the possibility of the effects of changes in oil prices on the dollar-won basis to potentially take distinct values depending on whether the level of oil prices is smaller (low oil price regime) or larger (high oil price regime) than the estimated threshold level of oil prices. Thus, the result supports the presence of threshold effect or different regimes in the effect of changes in oil prices on the basis, consistent with findings from the regime switching analysis. We now examine the effects of changes in oil prices on the basis of each regime or sample split to assess whether they are consistent with the view that the effects are generally not congruent in both regimes.

Table 5 displays the results in both regimes using the level of oil prices as the threshold variable or regime splitting cut off. As shown in the table, the median threshold estimate is around $55, and the test of no threshold effect yields a significant p-value. Thus, there is evidence of different regimes and the sample can be split into two groups. Periods with oil prices of more than the range of estimated threshold value are classified into high-oil price group (i.e. normal or elevated levels of oil prices in the market) while the ones with smaller values are classified into low-oil price group (i.e. low or depressed levels of oil prices).

Additionally, the coefficient on changes in oil prices is positive and significant for the high oil-price regime while it is negative and significant for the low-oil price regime. This suggests that the effects of changes in oil prices on dollar-won basis are not uniform across all levels of oil prices. They are non-linear and dependent on the regime of oil prices and the positive or tightening impact on dollar-won basis from increases in oil prices only kicks in after oil prices have exceeded a threshold level, consistent with the findings from the dummy variable regression analysis based on observation threshold. It is after oil prices have exceeded certain estimated threshold levels and transitioned into the high price regime that the kind of hedging decision which leads to tighter dollar-won basis begins to take place in the swap market. Until then, either such hedging does not fully occur, or it occurs in the reverse direction which leads to wider, rather than tighter, dollar-won basis. The other column reports the results after including control variables. The upshot of these results is that the threshold effects and previous conclusions generally remain intact, but the estimates appear slightly tempered as controls increase.

Overall, we find evidence that the effects of changes in oil prices on the dollar-won basis is regime-dependent. The threshold analysis quantifies and then characterizes what constitutes a high and low oil price regime. Using the threshold model, which supports the earlier observational analysis, we estimate a threshold oil price level of around $55. Oil prices below this level constitute the low oil price regime whereas oil prices above this level make up the high oil price regime. We show that hedging only begins to take place in ways that lead to tighter dollar-won basis when oil prices exceed the estimated threshold level and transition into the high oil price regime. This also seems to suggest that the currency hedging strategy of buying dollars forward occurs after oil prices have exceeded certain threshold levels of oil prices. Below this level, it is probable that the reverse hedging strategy which leads to wider dollar-won basis is more dominant.

5. Impulse response

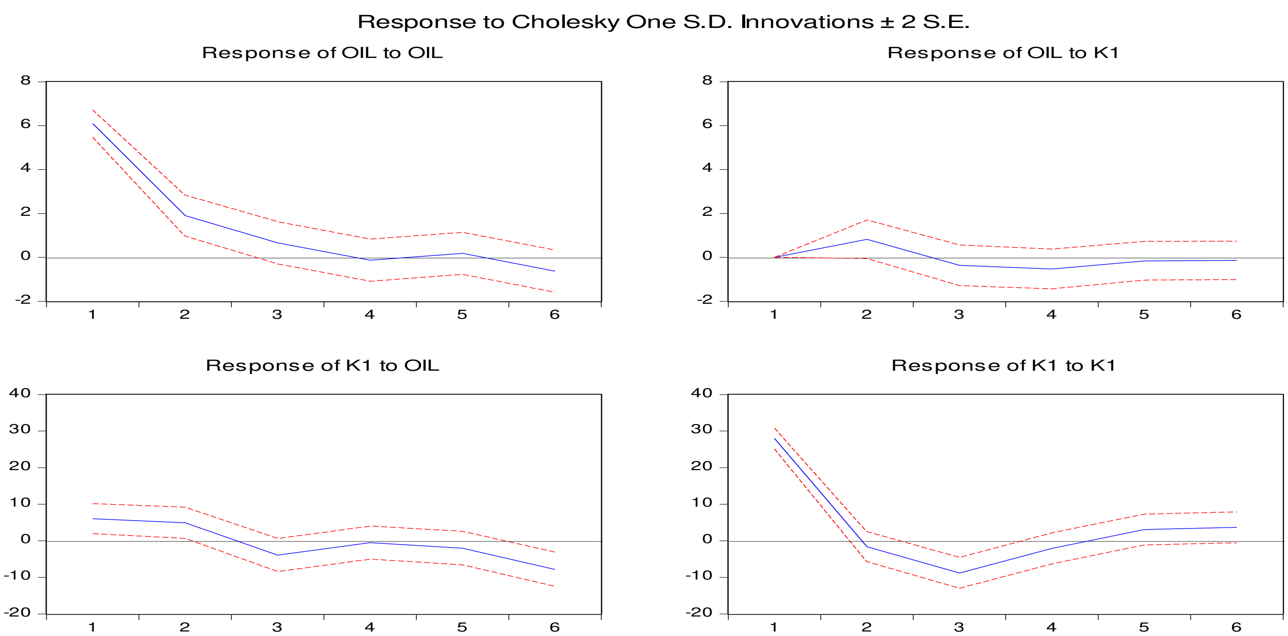
The main goal of this section is to examine the response of the dollar-won basis to oil price shocks. We specify a VAR model. In our specification of the VAR model, the ordering employed is such that shocks to crude oil prices influence changes in the dollar-won basis, but shocks to the dollar-won basis do not affect oil prices contemporaneously in the international commodities markets. This ordering reflects the view that oil prices are globally determined but can influence the decisions of oil importers; oil importers take prices as given and react to changes in or expected changes in oil prices because they do not have the power to influence these price changes in the international commodities markets[3].

5a. Main results

i. Impulse responses

This section presents the impulse responses of the dollar-won basis to shocks in oil prices. To this end, we estimate the above VAR model for the dollar-won basis (K1). After running the first stage VAR, the Akaike Information Criterion (AIC) suggests a lag length of 7. Accordingly, we choose this lag to specify the VAR, although we note that in an unreported robustness checks, we find that our main inference is largely robust to different lag lengths and not significantly altered.

Figure 4: Response changes in dollar-won basis (K1) to changes in oil prices (OIL)



Note: Solid lines (blue) are estimates of the impulse responses to a one standard deviation shock estimated using our VAR specification. Dashed lines (red) are the 95 percent confidence intervals. The vertical axis highlights the impulse responses of changes in the variables. Horizontal axis denotes months after a shock has occurred. For instance, a value of 1 in the horizontal axis will denote the response of the variable on the vertical axis to a shock that occurred 1 month earlier, i.e. the response to a shock one month after the shock took place.

Fig. 4 shows the responses of the dollar-won basis (K1) to a 1 standard deviation shock to oil price changes (OIL). A positive shock to OIL generates a positive impact response in K1, which implies that positive oil price shocks tightens K1. It tightens K1 basis by around 6 basis points on impact and continues the tightening in the subsequent two to three months. The peak is equivalent to a 6-basis point tightening which is stable until after the second year when it begins to collapse. This positive response is significant at the 5% level and continues for nearly 3 periods (months) before it turns insignificant by the third month. The significant positive and insignificant negative responses subsequently reversed, turning negative and significant

[3] Note, we do not employ long run identifying assumptions based on structural models as there is no economic theory on whose back restrictions can be imposed to achieve identification of parameters of structural VAR

after five months of the realization of the shock. This result echoes the previous findings and suggests that the response of the dollar-won basis to oil price shocks is dynamic and can either be positive or negative, depending on the period under study. By way of contrast, we note, as shown in Fig. 2, that shocks to the dollar-won basis fail to generate any statistically significant or economically meaningful response from changes in oil prices.

To summarize the results of the impulse response exercise, we find that the responses of the dollar-won cross-currency basis to oil prices shocks is dynamic and can either be positive, which implies a tighter dollar-won cross-currency basis from a positive oil price shock, or negative, which implies wider basis, across time. This provides evidence that there are certain periods wherein positive oil price shocks may lead to tighter basis, indicating active currency hedging activity in the dollar-won cross-currency swap market, or a negative or insignificant response of the basis, corresponding to inactive hedging or even opposite hedging activity in the dollar-won swap market.

6. Conclusion

Focusing on Korea, a major oil importer among G-20 countries, we examine the effect of changes in oil prices on the dollar-won basis swap spreads. We find evidence that an increase in oil prices is positively associated with the dollar-won basis only when oil prices have transitioned into a high regime, which implies that oil importers hedge against adverse movements in exchange rates when oil prices are in a high regime. However, when oil prices are low, such as during periods of depressed oil prices like those observed few years ago, we find no evidence that tighter dollar-won basis results from an increase in oil prices. Our results suggest that oil importers do not currency-hedge when oil prices are already in a depressed state, but they actively hedge against adverse exchange rate movements when oil prices have transitioned to a high regime.

Using threshold models, we formally verify the existence of threshold effects which enable us to quantify the regimes. We argue that it is when oil prices exceed $55 that oil importers become triggered to currency-hedge in the cross-currency swap markets, leading to a positive link between fluctuations in oil prices and changes in the dollar-won cross-currency basis. Much below this level, we find little or no evidence of active currency hedging in the swap market as reflected in a negative and sometimes insignificant effects of changes in oil prices on the basis. In a standard impulse-response framework, we find that the response of the dollar-won basis to oil prices shocks is dynamic; it can be positive, which implies a tighter dollar-won basis from positive oil price shocks, or negative, which implies a wider basis from positive shocks to oil prices. Thus, periods exist wherein positive oil price shocks lead to tighter basis, and other periods where such shocks can lead to either a wider basis or no significant response.

7. Appendix

i. Markov switching model

The Markov switching regression is suitable for our data and allows states to switch according to a Markov process. As an illustration, consider, for simplicity and without loss of generality, the problem of analyzing the links between $\{X_t, Y_t\}$, a bivariate time series. Our analysis is based on the following Markov switching regression model:

$$Y_t = \alpha_s + \beta_s X_t + \epsilon_{s,t}$$

where Y_t represents changes in the dollar-won basis swap spread, α_s is the state dependent intercept, X_t represents changes in oil prices, β_s is the state-dependent coefficient which measures the effect of fluctuations in oil prices on the cross-currency basis in different states or regimes and $\epsilon_{s,t}$ is the state-dependent error term such that $\epsilon_{s,t} \sim N(0, \sigma_s^2)$.
Partitioning the above into 2 states – state 1 and state 2, we have:

$$\alpha_s = \alpha_1,\ \beta_s = \ \beta_1 \text{ and } \epsilon_{s,t} = \epsilon_{1,t} \sim N(0, \sigma_1^2) \ \text{ if s} = 1$$
$$\alpha_s = \alpha_2,\ \beta_s = \ \beta_2 \text{ and } \epsilon_{s,t} = \epsilon_{2,t} \sim N(0, \sigma_2^2) \ \text{ if s} = 2$$

The nature of the current state is not known with certainty but estimates of the probability of currently being in one of the states can be estimated. Let δ_{ij}, where $i, j = 1$ or 2, represent estimate of the probability of moving from state i to state j, that is, the probability of being in state j in the current period given that the process was in state i in the previous period, then the matrix of the probability of transitioning from one state to another can be written as:

$$M = \begin{pmatrix} \delta_{11} & \delta_{12} \\ \delta_{21} & \delta_{22} \end{pmatrix}$$

where $\delta_{12} = 1 - \delta_{11}, \quad \delta_{22} = 1 - \delta_{21}$

δ_{11} gives the probability of remaining in state 1 if previously in state 1, and δ_{12} is thus the complement of δ_{11} and it represents the probability of not remaining in state 1 (i.e. going to state 2) if previously in state 1. Similarly, δ_{22} is the probability of remaining in state 2 if previously in state 2 and δ_{21} is the probability of not remaining in state 2 (i.e. reverting back to state 1) if previously in state 2. δ_{21} is thus a complement of δ_{22} and so $\delta_{21} = 1 - \delta_{22}$. In our application, the two states can be elevated and depressed states of oil prices wherein we study the effects of changes in oil prices on the currency hedging decisions (i.e. variations in the USDKRW cross-currency basis) in these states.

ii. Threshold model

Consider a threshold regression with two states or regimes characterized by a threshold γ which is the estimated level of oil prices serving as a switching variable that separates the data into two observable states. We can write this more instructively as:

$$Y_t = \beta_1 X_t + Z_t \psi_1 + \epsilon_t \qquad \text{if } \mathrm{th_t} \le \gamma$$

$$Y_t = \beta_2 X_t + Z_t \psi_2 + \epsilon_t \qquad \text{if } \mathrm{th_t} > \gamma$$

where Y_t is the dependent variable representing changes in Dollar-won basis; X_t is a vector of regressors or controls possibly containing lagged value of the dependent variable; Z_t represents the variable of interest (that is, changes in oil prices); $\mathrm{th_t}$ is the threshold variable (i.e. level of oil prices) and ϵ_t is IID error with mean 0 and variance σ^2.

To partition the samples into different states or regimes, the estimated value of the threshold ($\hat{\gamma}$) is required. The estimated $\hat{\gamma}$ must be within the range of values of the threshold variable $\mathrm{th_t}$. To estimate the threshold value, we minimize the least squares of the following regression with T observations and two states:

$$Y_t = \beta X_t + Z_t \psi_1 I(\mathrm{th_t} \le \gamma) + Z_t \psi_2 I(\mathrm{th_t} > \gamma) + \epsilon_t$$

for a sequence of T_1 values in $\mathrm{th_t}$, where $T_1 < T$.

The estimator for the threshold is given by:

$$\hat{\gamma} = \arg\min_{\gamma \epsilon \nabla} S_{T_1}(\gamma)$$

where $\nabla = (-\infty, +\infty)$,

$$S_{T_1}(\gamma) = \sum_{t=1}^{T} [Y_t - \beta X_t + Z_t \psi_1 I(\mathrm{th_t} \leq \gamma) + Z_t \psi_2 I(\mathrm{th_t} > \gamma)]^2$$

represents a $T_1 \times 1$ vector of sum of squared residuals and γ is a $T_1 \times 1$ vector of tentative thresholds. In the subsequent section below, we estimate the Markov switching and threshold models for our data.

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9. Highlights

- How do the cross-currency basis swap spreads of an oil-importing country change when oil prices rise?
- For Korea, we document a striking new evidence that currency hedging positions, via forward buying of US dollars, are taken in the swap market when oil prices increase, and this goes hand-in-hand with tighter dollar-won cross-currency basis spreads.
- However, these positions are taken only after oil prices have exceeded certain threshold levels and transitioned into a high-price regime. Until then, the effect on the basis is either negative, or altogether muted.
- This indicates that changes in the dollar-won basis and oil prices are dynamically related and regime dependent, where the relation is positive in one regime (high-price regime) but negative or insignificant in the other regime (low-price regime).
- One implication of this finding for risk management in portfolio strategy is to take long positions in Korean bonds hedged into US dollars with cross-currency basis swaps as soon as oil prices begin to show signs of transitioning into a high-price regime, and to take an opposite position otherwise.