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## **Second Response to Knittel and Smith**

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## Second Response to Knittel and Smith

Dermot Hayes

This paper provides an additional response to the recent paper by Knittel and Smith. Their paper contains statements that remain untrue, and their analysis contains errors in basic economics and econometrics. I demonstrate that the results in all three of the papers written by Professor Du and myself are reasonable, and that they can be used when appropriately qualified.

### Errors

In their response, the authors write that I did not cite errors in their first paper. I did show serious errors in their paper and will now describe them in more detail.

#### *Error in Basic Economics*

Knittel and Smith assume that for every one-penny change in output prices the profit of oil refiners also changes by one penny. This allows them to use expressions related to change in gasoline prices and changes in refiner's margin interchangeably. The entire first half of their sensitivity results are based on this assumption.

Refiners are multiple input, multiple output firms, and they have many ways to respond to a threat to their profits. In fact, had refiners not responded to the relative decline in gasoline prices they might not have survived.

To see how serious an error this is, apply the same assumption to an uninsured, drought-stricken crop producer. The result would be to conclude that profits in 2012 will be significantly higher than in previous years because crop prices have increased.

#### *Errors in Due Diligence*

When we estimated an equation with refiner's margin on the left-hand side, we reported the results in terms of the "change in refiner's margin." Knittel and Smith seem to have missed this, and concluded that we did not report these findings. In their paper, they mistakenly report these results as changes in gasoline price, and then accuse us of not reporting the results. They go so far as to say that it is "curious" that we did not report the results from this model. The only reason we do not report this change in refiner's margin as a gasoline price change is because we correctly realized that the two estimates were different.

#### *Errors in Basic Econometrics*

Of the seven alternative versions of our model that are presented in Knittel and Smith, four are based on the crack spread model, which as I have indicated above, does not explain changes in gasoline prices. The remaining three models all have crude oil on the left-hand side and the right-hand side of their estimated equation. In my first response I suggested that this will create a problem with endogeneity and bias their results. In their most recent response, they stand by this estimation procedure, stating "*Thus, there is no econometric problem with including it as an explanatory variable. Even if it were*

*endogenous, that is no reason to exclude it from the analysis.*" This response does not inform the reader that they did not correct for endogeneity.

In the appendix that follows, I test for endogeneity in their regression and show that the exogeneity of crude oil price is rejected at the 1% level. I then correct for this endogeneity and show that the corrected results are similar in magnitude to our original results.

Knittel and Smith say they recreated our model and replicated our results. They then present seven alternative models that purportedly show smaller results. As I have argued, four of these alternative models are based on their misinterpretation of the crack spread model, and the remaining three are biased due to endogeneity. What is missing from their analysis is an indication that our model could ever produce larger results. In the appendix to this paper I show that reasonable changes to our model structure provide larger results. If Knittel and Smith estimated versions of the model that had larger coefficients, they had an obligation to report them.

In the last section of their paper, Knittel and Smith present a set of equations with employment, natural gas, and age on the left-hand side. They then use our energy-based controls variables, while omitting relevant variables that might be expected to influence employment, natural gas, and age. Because our control variables were selected with reference to the energy market, they have no place in an equation that explains employment, natural gas, or age. In the absence of suitable controls, their regressions are obviously designed to find correlation between ethanol production and their dependent variable.

If Knittel and Smith truly are interested in objectively comparing models, they should do the following:

1. Include relevant control variables for each of the left-hand side variables and then report the significance of the ethanol production term.
2. Show that the model can explain employment at the regional level as we have done with ethanol.
3. Drop the first two years of data, and add two years of new data and show that the results are robust.

### **Our two gasoline price updates**

The most recent response by Knittel and Smith shifts attention away from our peer reviewed 2009 paper to the two updates we published as working papers. In my first response, I focused my efforts in showing that the model and econometrics in our 2009 paper were correct. I did this because the two updates use the same model and the same data series as the original paper. The updates simply drop two years of older data and add two years of new data to measure the updated coefficients.

In their response Knittel and Smith state about my first response that "*he offers no defense of the \$0.89 and \$1.09 numbers.*" This is untrue. In my first response I present a

graph that shows that the crack ratio has declined by about 30% throughout the estimation period. This relative decline in relative gasoline price motivated our work and is a key reason for the results we obtain. The continuation of the pattern in the more recent data supports the hypothesis that the same forces are in play throughout the period.

I had assumed that the reader would be able to apply a 30% price adjustment to current wholesale gasoline prices to see that the \$0.89 and \$1.09 numbers are reasonable.

Let me run the calculation. The average crack ratio from January 1986 to December 1999 was 1.56. The average crack ratio in the period from January 2008 to May 2012 was 1.19. In order to bring the crack ratio in the recent period up to the level of the historic period, the crack ratio needs to increase by 31%. This means that if wholesale gasoline prices had maintained their level relative to crude oil in the pre ethanol period they would be 31% higher than they are today. With wholesale gasoline selling in excess of \$3.14 per gallon, a 31% price increase represents an amount that is exactly in the range we reported.

But the marginal results are valid only if the forces that drove the estimated results remained in place for the entire period and if the impact is linear. So the use of these results must be qualified. As I mentioned in my first response, we provided ample and strong qualifications for the use of this procedure. Knittel and Smith attempt to refute our use of a qualifier by citing our description of the large results as reasonable. I do not see why a qualifier is made redundant by describing results as reasonable.

### **Inconsistency**

In my first response, I argued that the refiner's margin need not have fallen penny-for-penny with gasoline prices and showed that the profit they made from other distillates had increased. Knittel and Smith respond that "*we would conjecture that increased demand for clean-burning diesel vehicles, primarily in Europe, explains this phenomenon.*"

This line of argument is completely inconsistent. If stronger demand for diesel allowed refiners to charge more for diesel, then:

1. How can they then conclude that the refiner's margin adjusts penny for penny with gasoline price?
2. If one can argue that refiners adjust the source of their margins based on stronger demand, then why do Knittel and Smith oppose the concept that softer demand for gasoline would not cause the refiners to adjust in the other direction?
3. If demand for gasoline did not soften, why then did the refiners not maintain their gasoline margin?

### **The Funding Issue**

In my first response I indicated that it was highly unusual to say who is *not* funding a paper. Their response is that their disclosure statement is now standard practice. If this were true, then the same statement would be applied in their other working papers. None of the current working papers listed on their respective websites includes this disclosure.

## Conclusions

Knittel and Smith present seven alternative versions of our model, all of which apparently show a lower impact of ethanol production on gasoline prices. Four of these models are based on the flawed assumption that one can use the change in refiner's margin and the change in gasoline prices interchangeably. The remaining three models all suffer from an obvious endogeneity problem, which when corrected produces results that are similar to ours. What is then left of their paper is a series of entirely unrelated regressions where they regress unrelated variables against each other without appropriate controls, and with predictable results. I believe that the magnitude of all our results are reasonable and that they can be used in the current policy debates surrounding ethanol. Our results show that the closure of ethanol plants may have a serious impact on gasoline prices.

## Appendix

### Alternative specifications of our model that generate larger price impacts

Using the data from January 2000 to December 2010 as in Du and Hayes (2011) and Knittel and Smith, I now:

- (i) Add an explanatory variable measuring regional percent utilization of refinery operating capacity. The inclusion of this variable increases the estimated coefficient of ethanol production from -0.0000181 to -0.0000185. See Table 1.
- (ii) Replace the included regional imports of finished motor gasoline with US finished motor gasoline imports. This increases the estimate to -0.0000201.
- (iii) Combine the changes in (i) and (ii). This further increases the estimate to -0.0000204.

All these data are available to anyone with an interest, and I encourage the running of alternative model specifications to see how easy it is to find a larger estimate.

### The Endogeneity Issue in Knittel and Smith's Crack Ratio Model

Knittel and Smith included crude oil prices on **both** sides of the crack ratio model and in my original response, I pointed out that there is an obvious endogeneity problem with this specification. I also indicated that this will generate biased estimates of the model parameters.

To test and correct for this endogeneity, one first needs to find a valid instrumental variable that is correlated with the crude oil prices, but also exogenous to the model. Here the price of natural gas is a valid choice. Natural gas prices are strongly correlated with

the oil prices (see Figure 1), and it is reasonable to assume that the price of natural gas does not affect the price of gasoline relative to crude oil.

In the results shown in Table 2, I used the natural gas price, deflated by the consumer price index, as a proxy for the real crude oil prices. I then we use two-stage least squares to formally test for the endogeneity of crude oil price. The estimation results are reported in Table 2.

The F test statistic for excluded instruments (421.31) indicates that the real natural gas price is a good instrument for the real oil price. The crude oil price is found to be endogenous with the exogeneity hypothesis rejected at 0.01% level, and an endogeneity test statistic of 16.238.

The results in column (III) of Table 2 show that when I use the real natural gas price as a proxy for crude oil price, the estimated gasoline price impact is similar to the original estimate in our updated paper.

Also, after taking into account the endogeneity of crude oil prices using two-stage least squares, ethanol production has a statistically significant impact on gasoline prices and the magnitude of the impact increases from -0.00000992 in column (II) (the Knittel and Smith model) to -0.0000120 in column (IV).

I also added a lagged dependent variable to the model after taking into account the endogeneity of crude oil price. The results are reported in columns (V) and (VI) of Table 2. These results show smaller coefficients on the ethanol production and statistically significant lagged effects because the model attempts to capture dynamic features of the process. The results indicate that the “total effects” are realized in about three months and are in the similar magnitude to the previous static specifications.

**Table 1. Estimation results for the crack ratio model using alternative specifications**

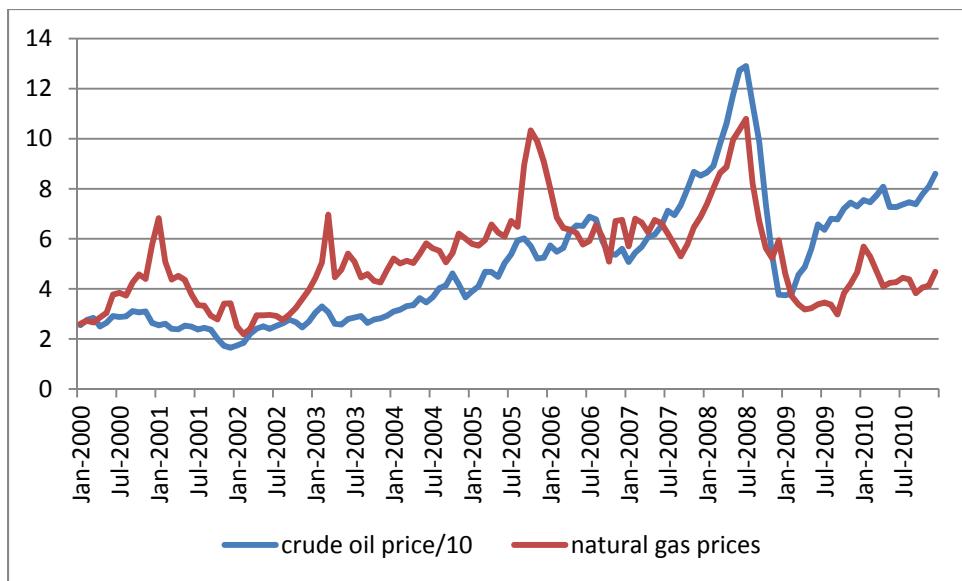
	Du and Hayes (2011)	Specification (i): add in regional capacity utilization percent	Specification (ii): replace regional gas imports by US imports	Specification (iii): combine changes in (i) and (ii)
Oil stock	3.42e-06***	3.39e-06***	3.15e-06***	3.14e-06***
Gasoline stock	-3.62e-07	-4.96e-08	-1.93e-07	1.11e-07
Equivalent Refinery capacity	1.18e-06	7.74e-07	1.00e-06	6.99e-07
Utilize percent		-0.001		-0.001
<b>Ethanol production</b>	<b>-.0000181***</b>	<b>-.0000185***</b>	<b>-.0000201***</b>	<b>-.0000204***</b>
Supply disruption	0.09**	0.08**	0.13**	0.12**
Gasoline import	-6.58e-06**	-5.78e-06**	-5.59e-06**	-5.21e-06**
HHI	5.13e-06	1.79e-06	5.96e-05	5.01e-05
January	0.004	0.001	0.005	0.001
February	0.01	0.006	0.006	0.002
March	0.08***	0.07***	0.08***	0.08***
April	0.13***	0.13***	0.14***	0.14***
May	0.16***	0.17***	0.17***	0.17***
June	0.11***	0.11***	0.11***	0.12***
July	0.06***	0.07***	0.07***	.07***
August	0.06***	0.07***	0.07***	.07***
September	0.07***	0.07***	0.07***	.07***
October	0.03	0.03	0.03	0.03
November	0.007	0.009	0.008	0.009

*Note:* Single (\*), double (\*\*), and triple (\*\*\*) asterisks denote significance at the 0.10, 0.05, and 0.01 levels, respectively.

**Table 2. Estimation results for the endogeneity of crude oil price in the crack ratio model**

	I	II	III	IV	V	VI
	Du and Hayes (2011)	Add real crude oil price as explanatory variable	Use real NG price as proxy for oil price	Use real NG price as IV	Use real NG price as proxy for oil price + lagged dependent variable	Use real NG price as IV + lagged dependent variable
Lagged dependent					0.68***	0.63***
Oil stock	3.42e-06***	1.17e-06*	2.23e-06***	1.74e-06***	6.49e-07	5.62e-07
Gasoline stock	-3.62e-07	-3.59e-06***	-2.89e-06*	-2.77e-06*	-5.56e-06***	-5.32e-06***
Refinery capacity	1.18e-06	1.10e-05***	7.16e-06***	8.54e-06***	4.59e-06***	5.30e-06***
Real oil price		-0.84***		-0.63***		-0.24***
Real NG price			-4.30***		-1.52***	
<b>Ethanol production</b>	<b>-.0000181***</b>	<b>-.00000992***</b>	<b>-.0000184***</b>	<b>-.0000120***</b>	<b>-.00000609***</b>	<b>-0.00000436***</b>
Supply disruption	0.09**	0.13***	0.18***	0.12***	0.09***	0.08***
Gasoline import	-6.58e-06**	-1.50e-06	-2.98e-06	-2.79e-06**	-1.82e-06	-1.81e-06
HHI	5.13e-06	9.81e-05***	6.31e-05*	7.44e-05**	1.9e-05	2.63e-05
January	0.004	0.01	0.002	0.01	0.05***	0.05***
February	0.01	0.03	0.003	0.02	0.04**	0.04***
March	0.08***	0.10***	0.07***	0.09***	0.07***	0.08***
April	0.13***	0.16***	0.12***	0.15***	0.09***	0.11***
May	0.16***	0.20***	0.16***	0.19***	0.08***	0.09***
June	0.11***	0.15***	0.10***	0.14***	0.01	0.03*
July	0.06***	0.10***	0.05***	0.09***	-0.01	0.007
August	0.06***	0.09***	0.04*	0.09***	0.01	0.03**
September	0.07***	0.09***	0.04*	0.09***	0.03*	0.05***
October	0.03	0.04	0.004	0.04***	-0.03*	-0.01
November	0.007	0.02	-0.00009	0.02	-0.01	-0.005
				“Total” effect	-0.0000190	-0.0000118

*Note:* (1) Single (\*), double (\*\*), and triple (\*\*\*) asterisks denote significance at the 0.10, 0.05, and 0.01 levels, respectively. (2) The IV estimation and tests are conducted using the STATA xtivreg2 command.



**Figure 1. Crude oil and natural gas prices, Jan. 2000 to Dec. 2010.**

Source: <http://www.eia.gov/petroleum/data.cfm#prices>