Environmental Regulations and the Increasing Seasonality of Gasoline Prices

Michael C. Davis *†

University of Missouri-Rolla

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Abstract

We analyze gasoline prices over the past 27 years and find that there has been an increase in the seasonal variation since 2000. This finding is attributed to an increase in the environmental regulations on gasoline during the summer months.

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Key Words: Gasoline prices, Seasonal adjustment, Error correction model

*Corresponding author: Michael C. Davis, 101 Harris Hall, Rolla, MO 65409, phone: (573)-341-6959, fax: (573)-341-4866, email: davismc@umr.edu.

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1 Introduction

Phase II of the Reformulated Gasoline (RFG) program of the 1990 Clean Air Act was implemented in 2000. Phase II placed stricter requirements on gasoline content for the summer months than for the winter months. This policy may have led to greater refining costs for summer gasoline and greater adjustment costs in the spring and fall. Our hypothesis is that gasoline prices show a greater amount of seasonal variation since the program went into effect.

Previous studies of gasoline prices either reject the presence of seasonal variation, or find statistically significant, but small, seasonal variation. Davis and Hamilton (2004) find no evidence of seasonality in their study of wholesale gasoline price responses to changes in refined prices. Chouinard and Perloff (2002) find statistically significant variation across monthly retail prices when looking at the period from 1989-1997, but the greatest variation is only a 5.7-cent difference between December and June.

2 Results

The price data are available from the Energy Information Agency (`www.eia.doe.gov`). The oil data are the domestic crude oil first purchase prices (measured in cents per barrel) and the gasoline data are the average monthly retail prices (measured in cents per gallon).

To analyze the changes in gas prices we perform ordinary least squares regressions of gasoline and oil on months as shown in Section 2.1. Since the price of gasoline responds to changes in oil prices, we also analyze the data with an error correction model allowing the price of gasoline to be dependent upon the price of oil and months of the year. This model is presented in Section 2.2.

2.1 OLS Estimation

The results of the regressions of the change in gasoline prices and the change in crude oil prices on months are presented in Table 1 for the periods 1978-2004, 1978-1999 and 2000-2004. Over the full sample there appears to be almost a 3-cent increase in gasoline prices each April and May. A Chow test (F-statistic=5.18, p-value$<$ 0.001) suggests that there was a break in the sample at the beginning of 2000 due to the change in environmental standards. Therefore, we estimate the same model dividing the data into before-the-breakpoint and after-the-breakpoint samples. The early sample shows small and insignificant differences across months whereas the later sample shows much greater variation across months, with prices rising by 9 cents in March and falling by 8 cents in December. Many of the monthly dummy variables in the later sample are significant, despite the small sample size.

The oil prices also exhibit an increased seasonality pattern. The F-statistic of a break in January 2000 is only 1.85, which is significant (p-value=.04), but not as dramatic as for the gasoline. Therefore, we conclude

Table 1: Ordinary Least Squares Regressions

	ΔGas 1978-2004	ΔGas 1978-1999	ΔGas 2000-2004	ΔOil 1978-2004	ΔOil 1978-1999	ΔOil 2000-2004
Constant	-2.26	-0.90	-8.24	-55.81	-31.63	-162.20
	(0.91)	(0.70)	(3.61)	(28.85)	(27.99)	(95.36)
January	2.18	0.03	11.64	87.07	41.00	289.80
	(1.29)	(0.99)	(5.10)	(40.79)	(39.58)	(134.86)
February	2.68	0.10	14.02	65.30	7.00	321.80
	(1.29)	(0.99)	(5.10)	(40.79)	(39.58)	(134.86)
March	3.40	0.25	17.24	42.96	8.32	195.40
	(1.29)	(0.99)	(5.10)	(40.79)	(39.58)	(134.86)
April	5.31	3.61	12.82	64.04	62.64	70.20
	(1.29)	(0.99)	(5.10)	(40.79)	(39.58)	(134.86)
May	5.35	3.52	13.42	89.44	43.91	289.80
	(1.29)	(0.99)	(5.10)	(40.79)	(39.58)	(134.86)
June	3.34	2.15	8.60	45.81	15.63	178.60
	(1.29)	(0.99)	(5.10)	(40.79)	(39.58)	(134.86)
July	1.03	0.65	2.74	75.15	45.32	206.40
	(1.29)	(0.99)	(5.10)	(40.79)	(39.58)	(134.86)
August	2.48	1.46	6.96	112.89	71.77	293.80
	(1.29)	(0.99)	(5.10)	(40.79)	(39.58)	(134.86)
September	3.52	1.23	13.60	101.96	87.23	166.80
	(1.29)	(0.99)	(5.10)	(40.79)	(39.58)	(134.86)
October	1.44	0.57	5.28	88.48	60.59	211.20
	(1.29)	(0.99)	(5.10)	(40.79)	(39.58)	(134.86)
November	1.13	0.48	4.02	5.59	-1.32	36.00
	(1.29)	(0.99)	(5.10)	(40.79)	(39.58)	(134.86)

Standard errors in parentheses.
The gasoline data are measured in cents per gallon and the oil data are in cents per barrel.

that oil price movements are not wholly responsible for the change in seasonality.

2.2 Error Correction Model

In order to examine the possibility that there has also been a change in the relationship between oil and gasoline, we estimate an error-correction model (ECM) based on the work of Engle and Granger (1987). Bachmeier and Griffin (2003) employ the ECM to analyze gasoline prices, using the price of crude oil to explain the spot price of gasoline with daily data.[1] The error correction model first regresses the level of the retail gasoline price (P_t^G) on the level of the crude oil price (P_t^O):

$$P_t^G = \alpha + \beta P_t^O + z_t \tag{1}$$

The residuals of the regression, z_t, are then included in the following regression of gasoline prices on oil prices:

$$\Delta P_t^G = \alpha + \beta_1 \Delta P_{t-1}^O + \beta_2 \Delta P_{t-2}^O + \beta_3 \Delta P_{t-1}^G + \beta_4 \Delta P_{t-2}^G + \theta z_{t-1} + \gamma \prime X_t + \epsilon_t \tag{2}$$

where X_t is a vector of monthly dummy variables to test for seasonal effects.

[1]We used the Johansen cointegration test to see if gasoline and oil were cointegrated. The results did not allow us to reject the null hypothesis of no cointegration, but since the p-value that there was no cointegrating relationship was 0.12, we followed the previous literature and used the ECM. We also looked at alternative methods, including simple OLS and regressing the markup on the months, which had similar results to those presented here.

The results of these regressions for the three periods are presented in Table 2. The results in column 1 show that there is some variation from month to month over the whole sample following the expected pattern of higher prices in the summer and lower prices in the winter. We again perform a Chow test on the point of the implementation of Phase II of the RFG program. The test has an F-statistic of 7.33 (p-value$<$ 0.001) which indicates that there was a break at that date.

During the earlier sample there is a slight rise in prices in the spring, with a return to previous levels in the fall and early winter. The fluctuations attributable to seasonality, though significant, are certainly not large. However, the later sample shows much larger swings from month to month with the price increasing by substantial amounts throughout the spring. The coefficients for the dummy variables for March, April, May and June are all greater than 8 cents, and the coefficient on each of these four months is significant.

In addition, we estimate the ECM excluding the monthly dummy variables. A Chow test on the presence of a structural break is significant with an F-statistic of 7.45 (p-value$<$ 0.001), suggesting that the break affected the pattern of gasoline in ways other than just through its seasonal pattern.

Table 2: Error Correction Model

	ΔGas 1978-2004	ΔGas 1978-1999	ΔGas 2000-2004
Constant	-1.162	-0.348	-5.747
	(0.670)	(0.457)	(2.723)
Δ Oil	0.013	0.009	0.017
	(0.001)	(0.001)	(0.004)
Δ Oil(-1)	0.007	0.007	-0.000
	(0.002)	(0.002)	(0.006)
Δ Oil(-2)	0.002	-0.000	0.001
	(0.002)	(0.002)	(0.006)
Δ Gas(-1)	0.261	0.322	0.353
	(0.057)	(0.062)	(0.152)
Δ Gas(-2)	-0.246	-0.180	-0.208
	(0.051)	(0.055)	(0.134)
Z(-1)	-0.026	-0.016	-0.424
	(0.012)	(0.010)	(0.137)
January	1.269	-0.068	6.017
	(0.947)	(0.650)	(3.916)
February	0.815	-0.334	2.820
	(0.955)	(0.656)	(4.025)
March	2.177	0.117	9.529
	(0.940)	(0.640)	(3.966)
April	3.925	2.895	9.984
	(0.942)	(0.640)	(3.902)
May	3.277	1.545	12.178
	(0.975)	(0.674)	(4.213)
June	2.130	1.256	8.849
	(0.979)	(0.668)	(4.298)
July	0.253	0.135	4.171
	(0.955)	(0.662)	(4.043)
August	1.156	0.704	5.153
	(0.953)	(0.657)	(3.892)
September	1.018	-0.408	9.099
	(0.941)	(0.643)	(3.717)
October	-0.818	-0.736	0.711
	(0.938)	(0.644)	(3.841)
November	0.855	0.115	4.983
	(0.943)	(0.640)	(3.829)

Standard errors in parentheses.
The gasoline data are measured in cents per gallon.

3 Discussion

There appears to have been an increase in the seasonal component of gasoline prices with and without the response to crude oil prices over the last five years. In Section 3.1 we discuss the possibility that environmental regulations are responsible. In Section 3.2 we suggest alternative hypotheses for the seasonal pattern.

3.1 Regulatory Changes

One likely cause of this increased seasonality in gasoline prices was the implementation of Phase II of the RFG provisions to the 1990 Clean Air Act. Bulow et al. (2003) show that these provisions had an effect on the price of gasoline in the Midwest in the summer of 2000, and Muehlegger (2004) showed that it caused greater price spikes in Wisconsin, Illinois and California. Though the regulations are limited to certain regions, their effects have likely increased the average price for the country. Also, different locations may use different fuels to meet the requirements of the program, increasing costs everywhere due to the loss of standardization in refining (Chakravorty and Nauges, 2004).

Switch-over costs for refineries and gasoline stations in April and May likely account for the run-up in costs as the locations begin to adjust to the summer fuels. Bulow et al. (2003) note that many stations run down their inventories of winter fuels to make way for the summer fuels.

Our findings are consistent with the behavior of gasoline stations under the RFG regulations. The month with the largest increase in price is May, the month when the stricter standards start for the wholesalers, though prices rise in April (as the firms begin to adjust to the stricter standards) and June (as the standards start for the retail gasoline stations) (EPA, 2001). Meanwhile, the downward seasonal adjustments take place from October through December, following the easing of the summer standards midway through September (EPA, 2001).

3.2 Other Explanations

An alternative explanation for the increased seasonality is that there was a large increase in natural gas prices in 2000. This explanation would be reasonable if increased natural gas prices caused increased demand for heating oil in the winter. In the refining process, heating oil and gasoline are produced together, and if the two products are complements of production, the price of gasoline will be lower in periods when heating oil is being used.

Two weaknesses undermine this explanation. First, Serletis and Rangel-Ruiz (2004) find little evidence of an interaction between crude oil and natural gas. Also, in Table 1 we show that crude oil exhibits a greater seasonal pattern as well. This finding is not consistent with greater demand for a crude oil product in the winter.

Another possible explanation is that the attacks on September 11, 2001 changed the travel patterns of citizens and increased the demand for gasoline in the summer months. [2] Air traffic (as measured by enplaned passengers) showed a precipitous decline in 2001 and 2002 (7 percent decline in 2001 and 3 percent decline in 2002), though it did begin to recover in 2003. Clearly travelers were avoiding air travel in 2001 and 2002, and since many vacations are timed for the summer, travelers may have driven more during those months.

However, the passenger car data do not support the 9/11 hypothesis. There seems to be little change from the trend line as the growth rates of highway miles traveled were 1.8 percent, 2.0 percent and 1.2 percent in 2001, 2002 and 2003 respectively. All of these were below the average growth rate from 1991-2000 of 2.4 percent. At present there is no evidence that a 9/11 effect can explain the rise in seasonality.

4 Conclusion

Our findings suggest that there has been an increase in the seasonality of gasoline prices in the last five years. We conclude that the heavier regulation placed on summer gasoline is the primary cause of this increase. Regardless of the cause of the increased seasonality, researchers of gasoline prices will need to account for seasonal variation and the apparent structural break in their future research on gasoline prices. Future work would include an analysis of regional gasoline prices to see if the seasonal effect is stronger in

[2] These data are available from the US Department of Transportation (http://www.bts.gov/).

regions of the country where the provisions of the environmental regulations are stricter.

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