COVID-19 and Daily Oil Price Pass-Through*

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Abstract

This paper investigates the (crude) oil price pass-through into gasoline spot and gasoline retail prices in the U.S. due to the effects of coronavirus disease 2019 (COVID-19). The investigation is achieved by using daily data in a structural vector autoregression framework. The oil price pass-through is measured as the cumulative impulse response of gasoline spot or gasoline retail prices divided by the cumulative impulse response of oil prices, both following a percentage change in total number of the U.S. COVID-19 cases. The results suggest evidence for complete pass-through of oil prices into gasoline spot prices, whereas the corresponding pass-through into gasoline retail prices is about 29 percent in the long run.

JEL Classification: Q41; Q43

Key Words: Pass-Through; Oil Prices; Gasoline Prices; Retail Prices; Spot Prices; Daily Data

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1 Introduction

Total number of coronavirus disease 2019 (COVID-19) cases in the U.S. has been recorded as more than 30 million as of April 2021 according to the Centers for Disease Control and Prevention.[1] This number is reflected as a substantial drop in the economic activity in the U.S. as individuals have voluntarily started experiencing social distancing to fight against COVID-19 and several layers of government in the U.S. have further implemented stay-at-home orders starting from March 2020 (e.g., Bartik, Bertrand, Cullen, Glaeser, Luca, and Stanton (2020), Coibion, Gorodnichenko, and Weber (2020), Kahn, Lange, and Wiczer (2020) or Kong and Prinz (2020)). This reduction in economic activity has also resulted in higher unemployment rates and thus lower overall expenditure of individuals (e.g., see Curdia (2020)). Accordingly, the demand for both crude oil and gasoline has been reduced dramatically, whereas supply shocks due to the OPEC disagreement starting from March 2020 have further contributed to the turmoil of crude oil prices around the globe.

As gasoline is by far the most important form of energy consumed in the U.S. (e.g., see Kilian (2008)), it is important from a consumer welfare point of view to understand the volatility in gasoline prices. Since crude oil is the main input in the production of gasoline and its price is determined globally, investigating the implications of oil price changes on gasoline prices is essential to conduct policy, especially for financially-vulnerable populations amid COVID-19.

Based on the strong volatility in oil and gasoline prices due to the COVID-19 crisis, this paper investigates the pass-through of crude oil prices into the U.S. gasoline spot and gasoline retail prices. This is achieved by using the implications of a structural vector autoregression

[1] This information has been obtained from https://covid.cdc.gov/covid-data-tracker/#cases_totalcases.

(SVAR) model as originally introduced in studies such as by Bernanke (1986), Blanchard and Watson (1986) and Sims et al. (1986), where weekly percentage changes of daily endogenous variables are used for the crude oil prices, gasoline spot prices, and gasoline retail prices. Weekly percentage changes in daily total number of COVID-19 cases in the U.S. enter as an exogenous variable in this framework.

This paper contributes to the literature in several dimensions. The main contribution is to consider COVID-19 cases as an exogenous variable, which is useful to identify the oil price pass-through into gasoline prices due to the COVID-19 pandemic. Another contribution is using daily data as things have changed quickly, especially at the beginning of the COVID-19 pandemic. Finally, this paper contributes by measuring the pass-through of crude oil prices into gasoline prices through the cumulative impulse response of gasoline prices divided by the cumulative response of crude oil prices, both following a percentage change in the U.S. COVID-19 cases. Although such an approach is similar to the one used in earlier studies such as by Shambaugh (2008), Forbes, Hjortsoe, and Nenova (2018) or Ha, Marc, and Yilmazkuday (2020) in the context of exchange rate pass-through and by Yilmazkuday (2019) in the context of oil price pass-through, to our knowledge, this is the first paper using it to investigate the oil price pass-through into gasoline prices caused by the COVID-19 pandemic.

The empirical results based on the crude oil price data of "Brent Spot Price FOB (Dollars per Barrel)" provide evidence for complete pass-through of crude oil prices into gasoline spot prices. In particular, 1% of a weekly increase in daily crude oil prices results in about 1.1% of a weekly increase in daily gasoline spot prices in the U.S. after one week, 1% after one month, and again 1% after two months. The results also suggest that the pass-through of oil prices into gasoline retail prices in the U.S. is incomplete, both in the short run and the long run. Specifically, 1% of a weekly increase in daily crude oil prices results in about 0.15% of a weekly increase in daily gasoline retail prices after one week, 0.29% after one month, and again 0.29% after two months. The empirical results are highly similar when the crude oil price data of "Cushing, OK WTI Spot Price FOB (Dollars per Barrel)" are used.

These estimates are in line with earlier studies in the literature, including Borenstein, Cameron, and Gilbert (1997) who have provided evidence for complete oil price pass-through into gasoline spot prices, or Meyler (2009), Blair, Campbell, and Mixon (2017) and Yilmazkuday (2019) who have provided evidence for incomplete oil price pass-through into gasoline retail prices. However, different from these studies, this paper has investigated the oil price pass through into gasoline prices caused by changes in the number of COVID-19 cases in the U.S. by using data at the daily frequency.

The rest of the paper is organized as follows. The next section introduces the methodology and the data set used. Section 3 depicts empirical results. Section 4 concludes.

2 Estimation Methodology and Data

The main objective of this paper is to estimate the oil price pass-through into gasoline spot and gasoline retail prices. These pass-through measures are estimated by using implications of the SVAR model represented as $z_t = (\Delta o_t, \Delta s_t, \Delta r_t)'$ based on daily data from the U.S., where Δo_t represents percentage changes in crude oil prices, Δs_t represents percentage changes in gasoline spot prices, and Δr_t represents percentage changes in gasoline retail prices.[2]

[2] Percentage changes are used to ensure that no root lies outside the unit circle. Accordingly, the estimated SVAR model satisfies the stability condition.

2.1 Estimation Methodology

In formal terms, the SVAR model is given by:

$$A_o z_t = a + \sum_{k=1}^{7} A_k z_{t-k} + \Phi \Delta c_t + u_t \tag{1}$$

where percentage changes in daily total COVID-19 cases in the U.S. Δc_t are included as an exogenous variable, and u_t is the vector of serially and mutually uncorrelated structural innovations. For estimation purposes, the model is expressed in reduced form as follows:

$$z_t = b + \sum_{k=1}^{7} B_k z_{t-k} + \Omega \Delta c_t + e_t \tag{2}$$

where $b = A_o^{-1} a$, $B_k = A_o^{-1} A_k$ for all k, and $\Omega = A_o^{-1} \Phi$. The number of lags (of 7) has been determined by minimizing the Deviance Information Criterion across alternative lags (between 1 and 14) of which details are given in Figure 1. The model variables are confirmed to be stable as none of the roots lie outside the unit circle. It is postulated that the structural impact multiplier matrix A_o^{-1} has a recursive structure such that the reduced form errors e_t can be decomposed according to $e_t = A_o^{-1} u_t$, where the sizes of shocks are standardized to unity (i.e., the identification is by triangular factorization).

The recursive structure imposed on A_o^{-1} requires an ordering of the variables used in the estimation for which we use the one that is already given in $z_t = (\Delta o_t, \Delta s_t, \Delta r_t)'$. In particular, crude oil prices are assumed to affect both gasoline spot and gasoline retail prices contemporaneously, and gasoline spot prices are assumed to affect gasoline retail prices contemporaneously, whereas gasoline retail prices cannot affect gasoline spot prices contemporaneously. The motivation behind this ordering comes from crude oil prices being determined globally, while gasoline spot and gasoline retail prices are determined within the U.S., as suggested in studies such as by Borenstein, Cameron, and Gilbert (1997). Similarly, gasoline spot prices are determined nationwide in the U.S., whereas retail prices are determined based on several other factors, including refinery-related costs, local taxes or local distribution costs (e.g., see Yilmazkuday and Yilmazkuday (2016), Yilmazkuday (2017) or Yilmazkuday and Yilmazkuday (2019)). Block exogeneity is also used to ensure that neither gasoline spot prices nor gasoline retail prices can affect crude oil prices at any time following a shock, since crude oil prices are determined globally.

The estimation is achieved by a Bayesian approach with independent normal-Wishart priors. This corresponds to generating posterior draws for the structural model parameters by transforming each reduced-form posterior draw. In particular, for each draw of the covariance matrix from its posterior distribution, the corresponding posterior draw for A_o^{-1} is constructed by using by triangular factorization so that the sizes of shocks are standardized to unity. In the Bayesian framework, a total of 2,000 samples are drawn, where a burn-in sample of 1,000 draws is discarded. The remaining 1,000 draws are used to determine the structural impulse responses that are necessary for estimating the oil price pass-through into gasoline spot and retail prices.

2.2 Data

For crude oil prices (to construct Δo_t), daily series of "Brent Spot Price FOB (Dollars per Barrel)" obtained from U.S. Energy Information Administration (EIA) are used; for robustness, daily series of "Cushing, OK WTI Spot Price FOB (Dollars per Barrel)" have also been used to measure crude oil prices. Daily gasoline spot prices (to construct Δs_t) are measured by "New York Harbor Conventional Gasoline Regular Spot Price FOB (Dollars per Gallon)" obtained from EIA. Daily gasoline retail prices (to construct Δr_t) are measured by "Regular Unleaded Gas Prices" obtained from http://fuelinsights.gasbuddy.com/. Daily total cases of COVID-19 in the U.S. (to construct Δc_t) are obtained from the web page of the Opportunity Insights Economic Tracker.[3]

The sample covers the daily period between December 31th, 2019 and March 31th, 2021. All daily series are converted into weekly percentage changes (by taking their log difference) so that they are robust to any seasonality concern by construction. The corresponding series that enter the estimation are given in Figure 2, where crude oil prices and gasoline prices are highly correlated. The increase in COVID-19 cases in the U.S. is negatively correlated with other series, especially during March 2020.

2.3 Measurement of Pass-Through

The oil price pass-through into gasoline spot prices (denoted by PS) is defined as the ratio of the cumulative impulse of gasoline spot prices divided by the cumulative response of oil prices, both following a percentage change in the U.S. COVID-19 cases:

$$PS = \frac{\text{Cumulative Response of Gasoline Spot Prices}}{\text{Cumulative Response of Oil Prices}} \tag{3}$$

which can be calculated for any period after the shock. Similarly, Oil price pass-through into gasoline retail prices (denoted by PR) is defined as the ratio of the cumulative impulse of gasoline retail prices divided by the cumulative response of oil prices, both following a

[3] The web page is https://www.tracktherecovery.org/.

percentage change in the U.S. COVID-19 cases:

$$PR = \frac{\text{Cumulative Response of Gasoline Retail Prices}}{\text{Cumulative Response of Oil Prices}} \tag{4}$$

This approach (of using ratios of cumulative responses) is similar to those in studies such as by Shambaugh (2008), Forbes, Hjortsoe, and Nenova (2018), Yilmazkuday (2019) or Ha, Marc, and Yilmazkuday (2020) who estimate exchange rate (or oil price) pass-through measures by using the cumulative response of consumer prices (or gasoline prices) divided by the cumulative response of the exchange rate (or oil prices), both following a common shock.

3 Estimation Results

In the Bayesian estimation, the right hand sides of Equations 3 and 4 are calculated for each of the 1,000 draws. While the median of each distribution is considered as the Bayesian estimator of oil price pass-through, the 16th and 84th quantiles of distributions are used to construct the 68% credible interval (which is the standard credible interval considered in the Bayesian literature). The corresponding oil price pass-through estimates are given in Table 1 as point estimates, and the corresponding continuous estimates are given in Figures 3-4.

Based on the empirical framework, it is expected that crude oil prices affect gasoline spot prices and gasoline retail prices positively (i.e., positive pass-through measures of PS and PR are expected). The main reason behind this expectation is that crude oil is the main input used in the production of gasoline. Despite this well-known expectation, the main objective here is to measure the magnitude of this positive effect that crude oil prices have on gasoline spot prices and gasoline retail prices. As it may take time for the effects of crude oil prices to show up on gasoline spot prices and gasoline retail prices (e.g., due to price stickiness as in studies such as by Davis and Hamilton (2004)), we consider alternative horizons following changes in COVID-19 cases.

According to Table 1, when "Brent Spot Price FOB (Dollars per Barrel)" are used as a measure of crude oil prices, PS is about 1.1 after one week, about 1 after one month, and about 1 after two months. Considering the way that the data series have been constructed, these numbers suggest that 1% of a weekly increase in daily crude oil prices results in about 1.1% of a weekly increase in daily gasoline spot prices after one week, about 1% of a weekly increase in daily gasoline spot prices after one month, and about 1% of a weekly increase in daily gasoline spot prices after two months. Therefore, also based on the corresponding credible intervals, there is evidence for complete pass-through of oil prices into gasoline spot prices in the long run. It is important to emphasize that all of these results are based on a percentage change in the U.S. COVID-19 cases according to Equation 3.

Also according to Table 1, PR is about 0.15 after one week, about 0.29 after one month, and again about 0.29 after two months. Considering the way that the data series have been constructed, these numbers suggest that 1% of a weekly increase in daily crude oil prices results in about 0.15% of a weekly increase in daily gasoline retail prices after one week, about 0.29% of a weekly increase in daily gasoline retail prices after one month, and about 0.29% of a weekly increase in daily gasoline retail prices after two months. Therefore, also based on the corresponding credible intervals, there is evidence for incomplete pass-through of oil prices into gasoline retail prices, both in the short run and the long run. Once again, these results are based on a percentage change in the U.S. COVID-19 cases according to Equation 4.

As is evident in Table 1 as well as in Figures 3-4, the results are highly similar when "Cushing, OK WTI Spot Price FOB (Dollars per Barrel)" are used as a measure of crude oil prices. These estimates are in line with earlier studies in the literature, including Borenstein, Cameron, and Gilbert (1997) who have provided evidence for complete oil price pass-through into gasoline spot prices, or Meyler (2009), Blair, Campbell, and Mixon (2017) and Yilmazkuday (2019) who have provided evidence for incomplete oil price pass-through into gasoline retail prices. However, different from these studies, this paper has investigated the oil price pass through into gasoline prices caused by changes in the number of COVID-19 cases in the U.S. by using data at the daily frequency.

4 Conclusion and Policy Implications

The coronavirus disease 2019 has acted like both a negative supply and a negative demand shock on the economic activity (e.g., see Baldwin and Tomiura (2020)). Based on a structural vector autoregression model, this paper has investigated the corresponding implications on the crude oil price pass-through into gasoline spot and gasoline retail prices in the U.S. using daily data. The oil price pass-through has been measured as the cumulative impulse response of gasoline spot or retail prices divided by the cumulative impulse response of oil prices, both following a percentage change in the total number of the U.S. COVID-19 cases.

The results suggest evidence for complete pass-through of oil prices into gasoline spot prices in the long run. In particular, 1% of a weekly increase in daily crude oil prices results in about 1.1% of a weekly increase in daily gasoline spot prices in the U.S. after one week, about 1% after one month, and again about 1% after two months. The results also suggest that the pass-through of oil prices into gasoline retail prices in the U.S. is incomplete, both in the short run and the long run. Specifically, 1% of a weekly increase in daily crude oil prices results in about 0.15% of a weekly increase in daily gasoline retail prices after one week, about 0.29% of a weekly increase in daily gasoline retail prices after one month, and again about 0.29% of a weekly increase in daily gasoline retail prices after two months.

As gasoline is by far the most important form of energy consumed in the U.S., the results have several policy implications regarding consumer welfare. In particular, as crude oil prices have decreased in early periods of the COVID-19 pandemic (in April 2020), this has been partly reflected as lower gasoline retail prices supporting the budget of financially-vulnerable populations. However, as crude oil prices have started increasing significantly after April 2020, policy makers can protect financially-vulnerable populations by providing them longer unemployment assistance, more direct deposits through COVID-19 stimulus packages or higher tax breaks regarding their gasoline consumption. In this context, future research can focus on how oil price pass-through differs across neighborhoods to determine how financially-vulnerable populations can be assisted better through these policy actions.

References

Baldwin, R., and E. Tomiura (2020): "Thinking ahead about the trade impact of COVID-19," *CEPR Press VoxEU. org.*

Bartik, A. W., M. Bertrand, Z. B. Cullen, E. L. Glaeser, M. Luca, and C. T. Stanton (2020): "How Are Small Businesses Adjusting to COVID-19? Early Evidence from a Survey," Working Paper 26989, National Bureau of Economic Research.

Bernanke, B. S. (1986): "Alternative explanations of the money-income correlation," in *Carnegie-Rochester Conference Series on Public Policy*, vol. 25, pp. 49–99. Elsevier.

Blair, B. F., R. C. Campbell, and P. A. Mixon (2017): "Price pass-through in US gasoline markets," *Energy Economics*, 65, 42–49.

Blanchard, O. J., and M. W. Watson (1986): "Are business cycles all alike?," in *The American business cycle: Continuity and change*, pp. 123–180. University of Chicago Press.

Borenstein, S., A. C. Cameron, and R. Gilbert (1997): "Do gasoline prices respond asymmetrically to crude oil price changes?," *The Quarterly journal of economics*, 112(1), 305–339.

Coibion, O., Y. Gorodnichenko, and M. Weber (2020): "Labor Markets During the COVID-19 Crisis: A Preliminary View," Working Paper 27017, National Bureau of Economic Research.

Curdia, V. (2020): "Mitigating COVID-19 effects with conventional monetary policy," *FRBSF Economic Letter*, 2020(09), 1–05.

Davis, M. C., and J. D. Hamilton (2004): "Why Are Prices Sticky? The Dynamics of Wholesale Gasoline Prices," *Journal of Money, Credit, & Banking*, 36(1), 17–17.

Forbes, K., I. Hjortsoe, and T. Nenova (2018): "The shocks matter: improving our estimates of exchange rate pass-through," *Journal of International Economics*, 114, 255–275.

Ha, J., S. M. Marc, and H. Yilmazkuday (2020): "Inflation and exchange rate pass-through," *Journal of International Money and Finance*, 105, 102187.

Kahn, L. B., F. Lange, and D. G. Wiczer (2020): "Labor Demand in the Time of COVID-19: Evidence from Vacancy Postings and UI Claims," Working Paper 27061, National Bureau of Economic Research.

Kilian, L. (2008): "The economic effects of energy price shocks," *Journal of Economic Literature*, 46(4), 871–909.

Kong, E., and D. Prinz (2020): "The impact of non-pharmaceutical interventions on unemployment during a pandemic," *Available at SSRN 3581254*.

Meyler, A. (2009): "The pass through of oil prices into euro area consumer liquid fuel prices in an environment of high and volatile oil prices," *Energy Economics*, 31(6), 867–881.

Shambaugh, J. (2008): "A new look at pass-through," *Journal of International Money and Finance*, 27(4), 560–591.

Sims, C. A., et al. (1986): "Are forecasting models usable for policy analysis?," *Quarterly Review*, 10(Win), 2–16.

Yilmazkuday, D., and H. Yilmazkuday (2016): "Understanding gasoline price dispersion," *The Annals of Regional Science*, 57(1), 223–252.

——— (2019): "Redistributive Effects of Gasoline Prices," *Networks and Spatial Economics*, 19(1), 109–124.

Yilmazkuday, H. (2017): "Asymmetric incidence of sales taxes: A short-run investigation of gasoline prices," *Journal of Economics and Business*, 91, 16–23.

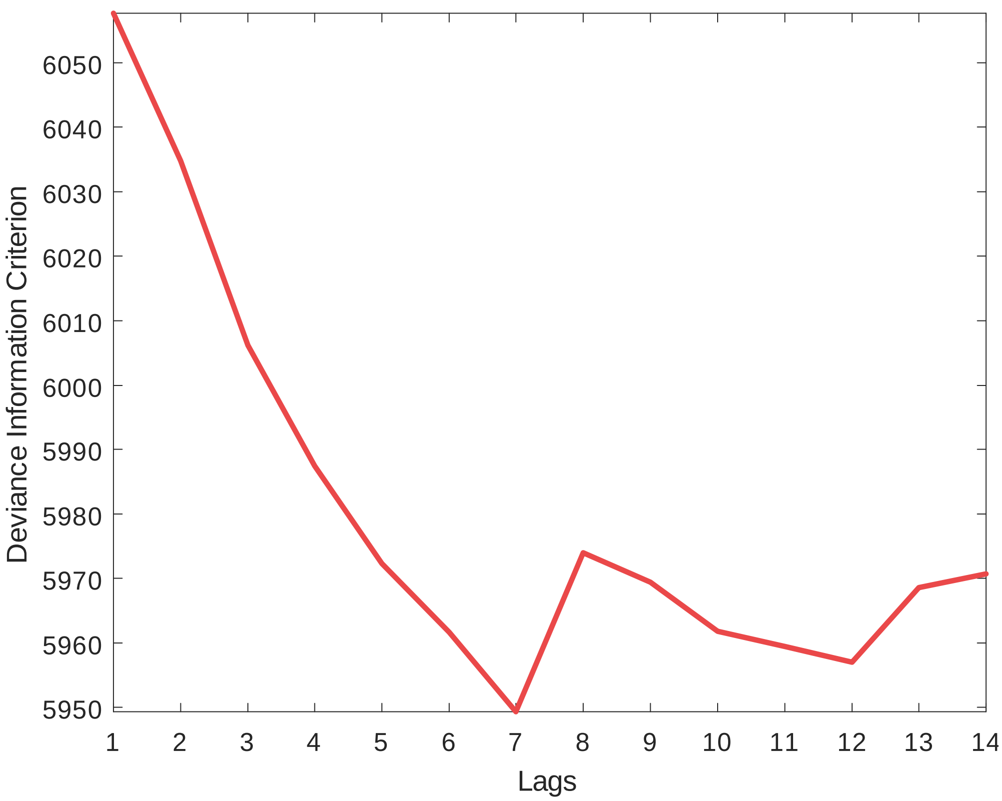
——— (2019): "Oil Price Pass-Through into Consumer Prices: Evidence from U.S. Weekly Data," *https://ssrn.com/abstract=3443245*.

Table 1 - Oil Price Pass-Through Estimates

	After 1 Week	After 1 Month	After 2 Months
Results with Brent Data			
Pass-Through into	1.132	1.000	1.003
Gasoline Spot Prices (PS)	$[0.895, 1.421]$	$[0.816, 1.199]$	$[0.821, 1.200]$
Pass-Through into	0.145	0.290	0.292
Gasoline Retail Prices (PR)	$[0.102, 0.202]$	$[0.236, 0.360]$	$[0.238, 0.363]$
Results with WTI Data			
Pass-Through into	1.298	1.129	1.128
Gasoline Spot Prices (PS)	$[0.984, 1.809]$	$[0.917, 1.529]$	$[0.915, 1.524]$
Pass-Through into	0.160	0.325	0.331
Gasoline Retail Prices (PR)	$[0.106, 0.246]$	$[0.249, 0.463]$	$[0.253, 0.471]$

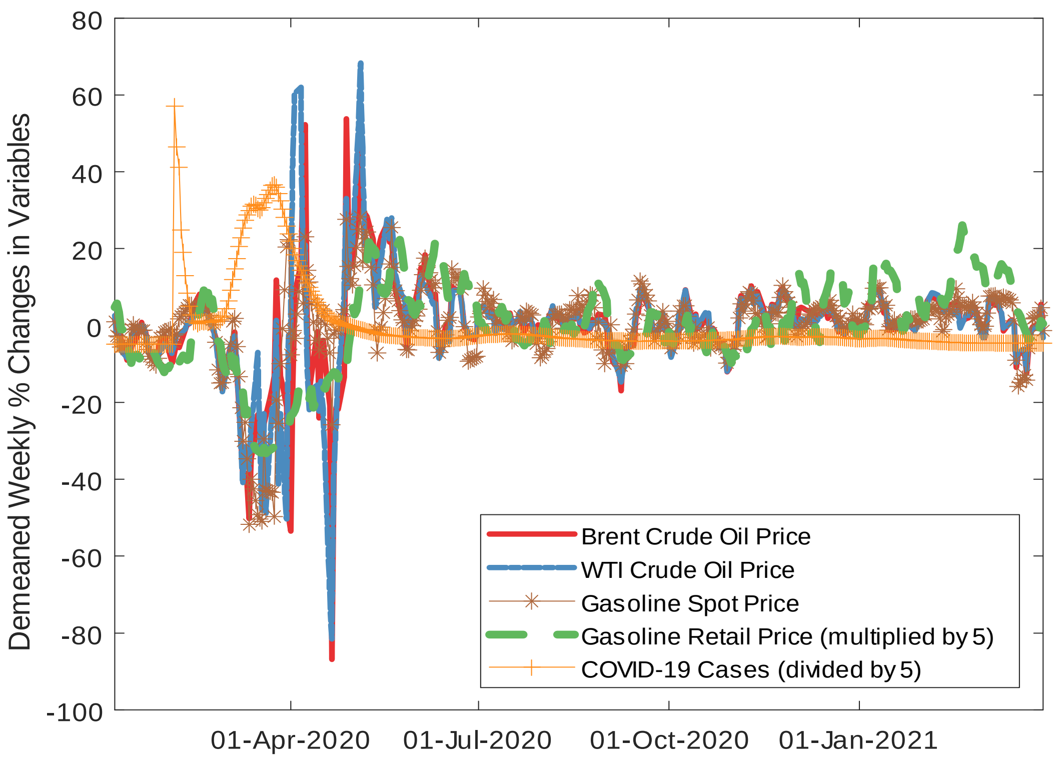
Notes: The estimates represent the median across 1,000 draws. Lower and upper bounds in brackets represent the 68% credible intervals.

Figure 1 - Lag Selection



Notes: Values represent Deviance Information Criterion for alternative lags.

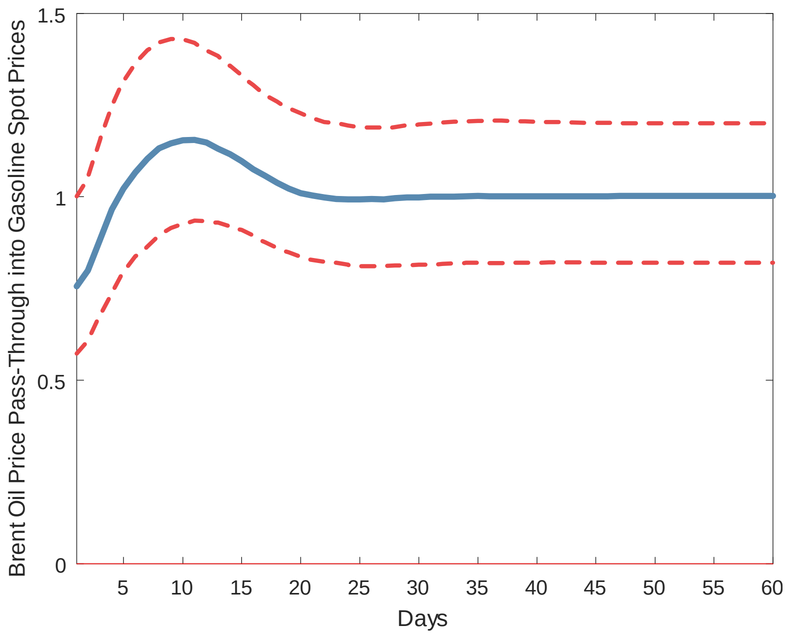
Figure 2 - Demeaned Weekly Percentage Changes of Daily Variables



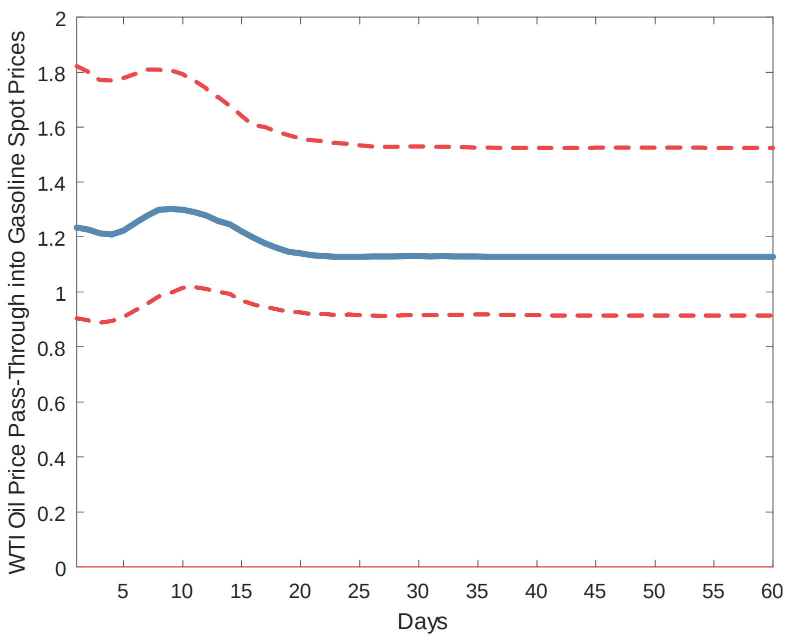
Notes: The series represent demeaned weekly percentage changes of daily variables. Measures of gasoline retail prices have been multiplied by 5, whereas those of COVID-19 cases have been divided by 5 for presentational purposes.

Figure 3 - Oil Price Pass-Through into Gasoline Spot Prices

Results with Brent Crude Oil Price Data



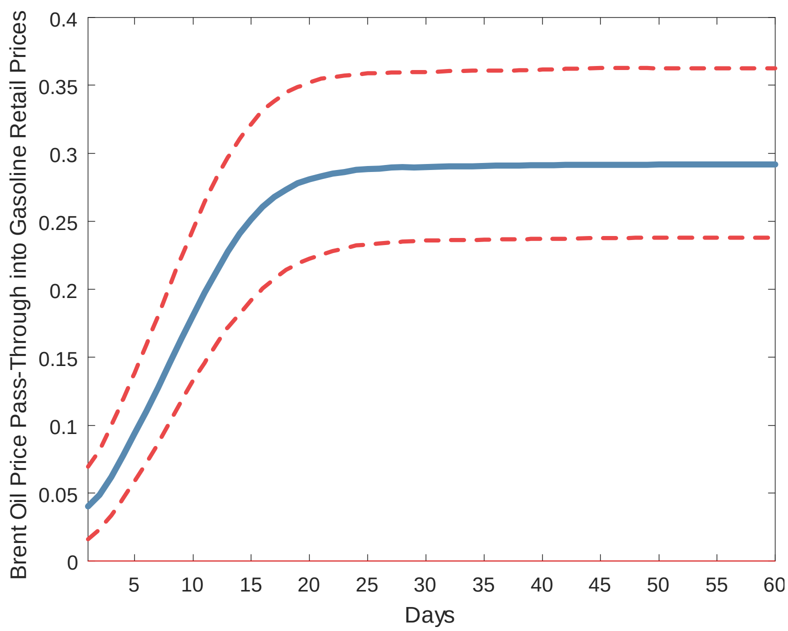
Results with WTI Crude Oil Price Data



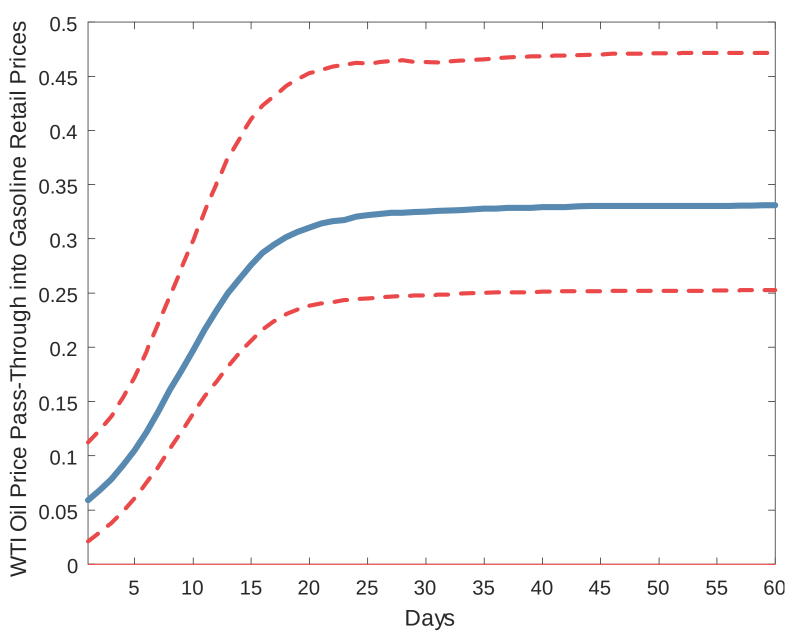
Notes: The solid lines represent the estimates. Dashed lines represent lower and upper bounds that correspond to the 68% credible intervals.

Figure 4 - Oil Price Pass-Through into Gasoline Retail Prices

Results with Brent Crude Oil Price Data



Results with WTI Crude Oil Price Data



Notes: The solid lines represent the estimates. Dashed lines represent lower and upper bounds that correspond to the 68% credible intervals.