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# The Surprising Stability Between Gas Prices and Expected Inflation

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## Abstract

We examine the correlation between nominal gas prices and consumer inflation expectations. Using data from the mid-1980s through the present, we do not find evidence that the relationship is time varying. Instead, our results suggest that the correlation between gas prices and inflation expectations is stable at approximately 0.30. Our results contribute to the vast literature regarding energy prices and the expectations augmented Phillips curve. We find very little evidence that the changing relationship between energy prices and inflation expectations has had any impact on the Phillip's curve or the missing inflation after the recession in 2008.

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# 1.0 Introduction

The importance of accounting for inflation expectations was recently highlighted in a series of papers by Coibion and Gorodnichenko (2015). Specifically, they argue and (provide compelling evidence) that the missing disinflation from the financial crisis can be explained by the subsequent rebound in oil prices that increased inflation expectations over the 2009-2011 time-period. The primary mechanism through which the rebound in oil prices increased inflation expectations (highlighted by Coibion and Gorodnichenko (2015) and Trehan (2011)) is the sensitivity of consumers inflation expectations to changes in gas prices. As outlined in Binder (2018), one theory as to why the consumers respond disproportionately to changes in gas prices is the “frequency hypothesis”, which argues that that because gas is purchased frequently, changes in gas prices have a larger impact on consumers inflationary expectations. However, Blanchard and Gali (2010), Blanchard and Riggi (2013), and Wong (2015) suggest that the link between changes in energy prices and inflation expectations is weak at best and may have altogether disappeared since the 1990s. Our aim in this paper is simply to examine the extent to which the reduced form correlation between inflation expectations and nominal gas prices is stable or the extent to which it is time varying. We note that while there appears to be disagreement in the literature regarding the extent to which changes in energy (gas) prices impact consumers’ inflation expectations, the papers implicitly assume that the correlation between changes in gas prices and inflation expectations has likely changed over time.

Our examination of existing work done on the relationship between energy prices and inflation expectation yielded a wide range of results. While most of the research agrees that the high correlation seen in the 1970’s and 1990’s has not sustained itself over time, the nature of a pass-through effect (stable or time varying) and the conditions which induce variation of one seem to be points of dispute. A paper by Sussman and Osnat (2015) concludes that correlation between oil prices and medium-term inflation expectations (which is a different inflation metrics than we employ) is time varying and has increased since the 2008 financial crisis. They argue that heightened public distrust in the monetary authority's ability to control inflation is the primary driver of this observation. Other work finds similar time variance in the correlation between oil price and expected inflation, but on the basis of price level magnitude or the direction of price changes. For instance, a model used by Hammoudeh, Shawkat, and Reboredo (2018) found that the intensity of a pass-through effect (severity of the correlation) was greater when the price of oil was above 67 USD per barrel. Findings from a paper done by Choi, Sangyup, Furceri, Loungani, Mishra, and Poplawski-Ribeiro (2018) suggest asymmetry in the relationship between oil price and inflation expectations. According to their model, oil prices increases led to greater correlation than did price decreases. Our research differs from the previous studies in that we focus on the correlation in the retail side of the oil market (i.e. unleaded gas prices) and inflation expectations rather than the spot price of crude.

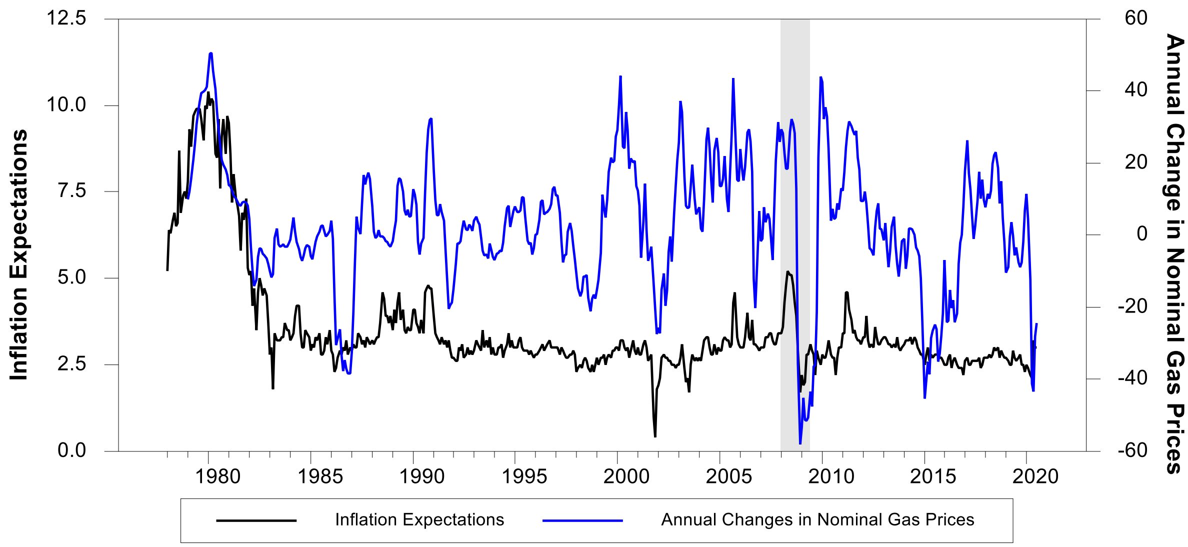
Given the changes in technology in the energy sector (fracking), changes in geopolitics in oil producing countries since 1980 (two Gulf Wars and the Arab Spring), and advances in the transparency of monetary policy, it is not unreasonable to posit (or even expect) a changing relationship between gas prices and inflation expectations. While the use of multivariate GARCH models in the analysis of the energy sector has exploded over the past 15 years, to our surprise, relatively few papers first test the null hypothesis of a constant correlation of the variables. As such, our primary hypothesis of interest in this paper is whether the correlation between inflation expectations and gas prices is constant or time varying. To test this hypothesis, we use the monthly Michigan consumer inflation expectation survey and nominal gas prices data over the 1978 – 2019 time-period. We utilize multivariate GARCH models in conjunction with Tse's (2000) *lm* test for constant correlation against the hypothesis of a time-varying relationship. To our surprise, we are not able to reject the null hypothesis of a constant correlation over our sample time-period. For robustness, we also estimate Engle's (2003) DCC Multivariate GARCH model allowing for time-varying correlations. We find the correlations from the DCC multivariate GARCH model to nearly always be within one-standard deviation of the correlation from the CC model. Our results suggest that the correlation between changes in gas prices and inflation expectation is approximately 0.3 and quite stable. The rest of the paper proceeds as follows: section 2 discusses our data and methodology, section 3 presents our results and policy implications, and section 4 concludes.

## 2.0 Data and Methodology

*2.1 Data*

We obtained monthly data the expected price change over the next 12 months from the University of Michigan consumer survey and the average price of unleaded gasoline from the St. Louis Fred database. Figure 1 displays the data with inflation expectations in black measured on the left-hand axis and the annual change in nominal gasoline prices in blue on the right-hand axis with the Global Financial Crisis highlighted by the gray shaded area. Given the sharp (and well-known structural break) in inflation expectations due to the Volker disinflation in the early 1980s, we chose to begin our empirical analysis in 1983.

Figure 1: University of Michigan Inflation Expectations and Annual Changes inNominal Gasoline Prices




*2.1 Methodology*

Let $\boldsymbol{y_t} = [y_{1t,}y_{2t}]'$ be a 2x1 vector containing the data series. We represent the conditional mean equations by the following reduced-form VAR:

$$A(L)\boldsymbol{y_t} = \boldsymbol{\varepsilon_t} \qquad \varepsilon_t \sim N(0, H_t) \qquad t = 1, \ldots..T \tag{1}$$

where *A(L)* is a matrix in the lag operator *L*, and $\boldsymbol{\varepsilon_t} = [\varepsilon_{1t}, \varepsilon_{2t}]'$ is a vector of innovations. We first estimate a Constant Correlation Model, as described in Enders (2010), such that the conditional covariances are modeled as

$$h_{iit} = c_{i0} + \alpha_{ii}\varepsilon_{it-1}^2 + \beta_{\text{ii}}h_{iit-1} \qquad (\ i = 1{,}2) \tag{2}$$

$$h_{ijt} = \ \rho_{\text{ij}}(h_{iit}h_{jjt})^{.0.5} \qquad (\ i \neq j) \tag{3}$$

Second, and for robustness, we also estimate Engle's (2003) DCC multivariate GARCH model. As such, the $\boldsymbol{\varepsilon_t}$ vector in (1) has the following conditional variance-covariance matrix:

$$H_t = D_tR_tD_t$$

where $D_t = diag\{\sqrt{h_{it}}\}$ is a 2x2 matrix containing the time-varying standard deviations from univariate GARCH models and $R_t = \{\rho_{ij}\}_t$ for $i, j$ = 1, 2 is a correlation matrix containing conditional correlation coefficients. The standard deviations in $D_t$ are governed by the following univariate GARCH*(P,Q)* process:

$$h_{it} = \gamma_i + \sum_{p=1}^{P_i} \alpha_{ip} \varepsilon_{it-p}^2 + \sum_{q=1}^{Q_i} \beta_{\mathrm{iq}} h_{iq-q} \qquad \forall\, i = 1,2. \tag{2}$$

Engle's (2002) framework consists of the following *DCC(M,N)* structure:

$$R_t = Q_t^{*-1}\, Q_t\, Q_t^{*-1},$$

where

$$Q_t = \left(1 - \sum_{m=1}^{M} a_m - \sum_{n=1}^{N} b_n\right)\overline{Q} + \sum_{m=1}^{M} a_m\,(\varepsilon_{t-m}\varepsilon_{t-m}) + \sum_{n=1}^{N} b_n\, Q_{t-n}. \tag{3}$$

$\overline{Q}$ is the time-invariant variance-covariance obtained from estimating (2), and $Q_t^*$ is a 2x2 diagonal matrix containing the square root of the diagonal elements of $Q_t$. Our primary focus is on the conditional correlation $\rho_{12,t} = q_{12,t}/\sqrt{q_{11,t}q_{22,t}}$ in $R_t$.

# 3.0 Results

Because our data is time-series, we follow the empirical strategy outlined in Enders (2010). That is, we (1) test both time series for unit roots (2) test each series for ARCH errors and (3) estimate our multivariate GARCH models outlined above while ensuring that the standardized and squared standardized residuals do not contain any serial correlation.

**Table I: Unit Root and Heteroskedasticity Tests**

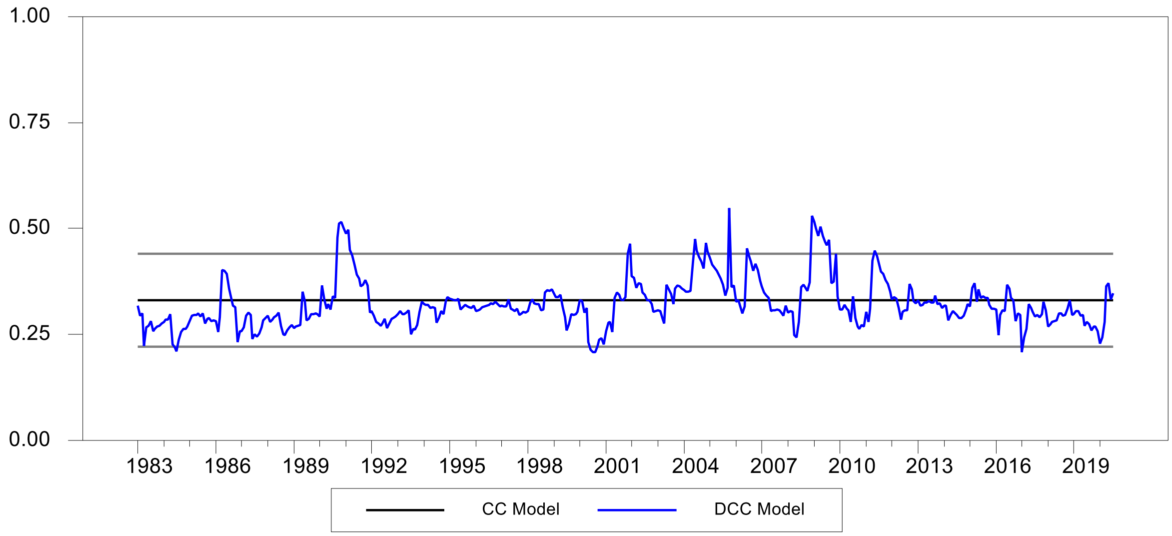
| *Unit Root Test:* | *Variable:* | |
|---|---|---|
| | *Inflation Expectations* | *Gasoline Prices* |
| *Augmented Dickey-Fuller Test* | -4.05** | -1.91 |
| ***Heteroskedasticity Test:*** | ***Variable:*** | |
| | *Inflation Expectations* | *Annual Change Gasoline Prices* |
| *ARCH (12) LM Test* | 243.794*** | 371.40*** |

***, **,* denotes significance at the 99%, 95%, and 90% levels.

Panel A of Table I displays the results from our unit roots as well as our ARCH effects. As can be seen, we are able to reject the null hypothesis of a unit root for our inflation expectations measure but not for gasoline prices. As such, we take transform the data into annualized changes in nominal gas prices. Panel B of Table I displays the ARCH tests. As can be seen, both series exhibit considerable heteroskedasticity.

We subsequently estimate our Conditional Correlation model. We included 12 lags of each respective variables in the mean equations to ensure that the standardized residuals were rid of serial correlation. Table II displays the estimates from our results. Panel A displays the results from the mean equation and Panel B displays the results from the variance equations. Panel C displays the Tse's (2000) chi-square test for a constant correlation. As can be seen from Panels A and B, out model is well estimated. Surprisingly, as can be seen in Panel C, we are not able to reject the null hypothesis of a constant correlation. As can be seen, the correlation between gas prices and expected inflation is remarkably stable using both models at approximately 0.3. We believe that this result could be a feature due to the cyclical nature of commodity cycles. That is, rapidly increasing gas prices induces

**Figure 2: Correlations from the Constant Correlation (CC) Model and Dynamic Conditional Correlation (DCC) Models**




# 4.0 Conclusion

We have used two multivariate GARCH models to examine the correlation between changes in nominal gas prices and consumers inflation expectations. Our results suggest that the relationship does not appear to be time varying. The correlation increases around crisis dates (i.e. the first Gulf War and the Global Financial crisis) but seems to be remarkably stable at approximately 0.3.

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**Table II: Conditional Correlation Model**

| Panel A: Mean Equations | | | | | |
|---|---|---|---|---|---|
| Inflation Expectations | | | Annual Change in Nominal Gas Prices | | |
| | Coefficient | Std. Error | | Coefficient | Std. Error |
| $Inf_{t-1}$ | 0.550 | 0.072 | $Inf_{t-1}$ | -0.219 | 0.966 |
| $Inf_{t-2}$ | 0.202 | 0.076 | $Inf_{t-2}$ | 1.109 | 1.012 |
| $Inf_{t-3}$ | 0.009 | 0.067 | $Inf_{t-3}$ | -0.380 | 1.014 |
| $Inf_{t-4}$ | -0.117 | 0.055 | $Inf_{t-4}$ | -0.163 | 1.166 |
| $Inf_{t-5}$ | 0.048 | 0.050 | $Inf_{t-5}$ | -0.160 | 0.954 |
| $Inf_{t-6}$ | 0.096 | 0.048 | $Inf_{t-6}$ | 1.598 | 1.064 |
| $Inf_{t-7}$ | -0.030 | 0.055 | $Inf_{t-7}$ | -0.673 | 1.069 |
| $Inf_{t-8}$ | -0.012 | 0.045 | $Inf_{t-8}$ | -1.236 | 0.883 |
| $Inf_{t-9}$ | -0.041 | 0.056 | $Inf_{t-9}$ | 0.542 | 0.905 |
| $Inf_{t-10}$ | 0.143 | 0.054 | $Inf_{t-10}$ | 1.417 | 0.983 |
| $Inf_{t-11}$ | -0.038 | 0.043 | $Inf_{t-11}$ | -1.774 | 0.915 |
| $Inf_{t-12}$ | 0.093 | 0.036 | $Inf_{t-12}$ | -0.538 | 0.952 |
| $Gas_{t-1}$ | 0.003 | 0.002 | $Gas_{t-1}$ | 1.300 | 0.066 |
| $Gas_{t-2}$ | 0.000 | 0.003 | $Gas_{t-2}$ | -0.633 | 0.104 |
| $Gas_{t-3}$ | 0.001 | 0.004 | $Gas_{t-3}$ | 0.259 | 0.101 |
| $Gas_{t-4}$ | -0.002 | 0.003 | $Gas_{t-4}$ | -0.034 | 0.096 |
| $Gas_{t-5}$ | -0.002 | 0.003 | $Gas_{t-5}$ | -0.056 | 0.085 |
| $Gas_{t-6}$ | 0.005 | 0.003 | $Gas_{t-6}$ | 0.087 | 0.082 |
| $Gas_{t-7}$ | -0.003 | 0.003 | $Gas_{t-7}$ | -0.036 | 0.079 |
| $Gas_{t-8}$ | -0.001 | 0.003 | $Gas_{t-8}$ | -0.100 | 0.072 |
| $Gas_{t-9}$ | 0.003 | 0.003 | $Gas_{t-9}$ | 0.198 | 0.075 |
| $Gas_{t-10}$ | -0.008 | 0.003 | $Gas_{t-10}$ | -0.123 | 0.071 |
| $Gas_{t-11}$ | 0.012 | 0.003 | $Gas_{t-11}$ | 0.027 | 0.063 |
| $Gas_{t-12}$ | -0.007 | 0.002 | $Gas_{t-12}$ | -0.051 | 0.041 |
| Constant | 0.267 | 0.089 | Constant | 1.539 | 1.957 |
| **Panel B: Variance Equation** | | | | | |
| C | 0.026 | 0.005 | C | 2.085 | 0.632 |
| α | 0.839 | 0.083 | α | 0.362 | 0.046 |
| β | 0.161 | 0.083 | β | 0.638 | 0.046 |
| R(2,1) | 0.344 | 0.055 | | | |

Panel C: Tse Test for Constant Correlation

| | Test Statistics | P-Value |
|---|---|---|
| $\chi^2$ | 0.073 | 0.785 |

**Table III: DCC Model**

| Panel A: Mean Equations | | | | | |
|---|---|---|---|---|---|
| | Inflation Expectations | | | Annual Change in Nominal Gas Prices | |
| | Coefficient | Std. Error | | Coefficient | Std. Error |
| $Inf_{t-1}$ | 0.635 | 0.005 | $Inf_{t-1}$ | -0.025 | 0.096 |
| $Inf_{t-2}$ | 0.162 | 0.004 | $Inf_{t-2}$ | 1.390 | 0.074 |
| $Inf_{t-3}$ | -0.069 | 0.003 | $Inf_{t-3}$ | -1.529 | 0.065 |
| $Inf_{t-4}$ | 0.066 | 0.003 | $Inf_{t-4}$ | 1.528 | 0.063 |
| $Inf_{t-5}$ | -0.078 | 0.003 | $Inf_{t-5}$ | -1.124 | 0.076 |
| $Inf_{t-6}$ | 0.054 | 0.004 | $Inf_{t-6}$ | 1.908 | 0.060 |
| $Inf_{t-7}$ | 0.131 | 0.003 | $Inf_{t-7}$ | -0.483 | 0.060 |
| $Inf_{t-8}$ | -0.074 | 0.003 | $Inf_{t-8}$ | -0.993 | 0.082 |
| $Inf_{t-9}$ | -0.102 | 0.003 | $Inf_{t-9}$ | 0.553 | 0.060 |
| $Inf_{t-10}$ | 0.204 | 0.003 | $Inf_{t-10}$ | 1.090 | 0.062 |
| $Inf_{t-11}$ | -0.002 | 0.003 | $Inf_{t-11}$ | -1.555 | 0.068 |
| $Inf_{t-12}$ | -0.017 | 0.003 | $Inf_{t-12}$ | -1.051 | 0.059 |
| $Gas_{t-1}$ | 0.004 | 0.001 | $Gas_{t-1}$ | 1.330 | 0.018 |
| $Gas_{t-2}$ | -0.004 | 0.001 | $Gas_{t-2}$ | -0.696 | 0.016 |
| $Gas_{t-3}$ | 0.009 | 0.001 | $Gas_{t-3}$ | 0.340 | 0.018 |
| $Gas_{t-4}$ | -0.010 | 0.001 | $Gas_{t-4}$ | -0.087 | 0.019 |
| $Gas_{t-5}$ | 0.001 | 0.001 | $Gas_{t-5}$ | -0.059 | 0.017 |
| $Gas_{t-6}$ | 0.000 | 0.001 | $Gas_{t-6}$ | 0.068 | 0.021 |
| $Gas_{t-7}$ | 0.005 | 0.001 | $Gas_{t-7}$ | -0.001 | 0.016 |
| $Gas_{t-8}$ | -0.008 | 0.001 | $Gas_{t-8}$ | -0.131 | 0.016 |
| $Gas_{t-9}$ | 0.009 | 0.001 | $Gas_{t-9}$ | 0.194 | 0.016 |
| $Gas_{t-10}$ | -0.008 | 0.001 | $Gas_{t-10}$ | -0.045 | 0.014 |
| $Gas_{t-11}$ | 0.004 | 0.001 | $Gas_{t-11}$ | -0.073 | 0.019 |
| $Gas_{t-12}$ | 0.000 | 0.001 | $Gas_{t-12}$ | 0.001 | 0.015 |
| Constant | 0.259 | 0.018 | Constant | 1.011 | 0.192 |
| **Panel B: Variance Equation** | | | | | |
| C | 0.007 | 0.001 | C | 1.395 | 0.268 |
| α | 0.297 | 0.017 | α | 0.352 | 0.028 |
| β | 0.688 | 0.020 | β | 0.687 | 0.023 |
| DCC(A) | 0.004 | 0.005 | | | |
| DCC(B) | 0.996 | 0.011 | | | |