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Hurricane forecast revisions and petroleum refiner equity returns

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ABSTRACT

We test the return reaction of an index of petroleum refining firms to the official forecast revisions for major tropical storms in the refinery-dense region of the northwest Gulf of Mexico. First, we find that improvements in official hurricane forecasts over the last twenty years have had a direct effect on when asset prices react in anticipation of tropical storms. In the 1990s, traders react to forecasts at the 24-hour horizon. A decade later they react earlier — price movements in the 2000s react to forecast information at the 48-hour horizon. Second, we find that the effect of upward revisions in storm intensity is associated with *increases* in the returns to our index. These increases only accrue to large firms, perhaps due to these firms' ability to utilize geographic diversification and previously idle capacity to take advantage of storm-induced increases in refined petroleum prices.

1. Introduction

Research has previously shown that energy prices react to hurricanes and tropical storms in anticipation of the arrival of the storm. We examine equity returns to petroleum refining firms and perform comprehensive tests of *when* prices react to tropical storm forecast information potentially portending catastrophic outcomes for refineries. While we find that, consistent with Ewing et al. (2006) and Fink et al. (2010), market participants rationally react to publicly available storm forecasts, the time of reaction has changed over the last two decades. The track accuracy of National Hurricane Center (NHC) forecasts has increased significantly over that time. While in 1990 the official 48-hour NHC forecast had an average error of about 194 nautical miles (NM), by 2009 this error had been reduced to about 70 NM.[1] We test whether this forecast quality improvement is related to the change in market return reactions to the forecasts, and find that the two are directly linked.

Further, firm returns in response to these forecasts move in a perhaps unexpected direction. Large firms counter-intuitively exhibit a positive return response in anticipation of the arrival of tropical storms in the refinery dense region of the Gulf of Mexico, while small firms exhibit no reliable reaction at all. The natural expectation for the direction of the response is that returns to refining firms in these circumstances would be negative. It appears that the elasticity of refined petroleum is such that the loss of refining capacity has a positive effect on the price, and that large, geographically-diverse firms and firms with idle capacity stand to benefit.

Most studies of market reaction to catastrophic events tend to fall into two broad categories. The first category consists of case studies that focus on a single major event and dissect market behavior around it. Barrett et al. (1986) (investigating the behavior of bond markets in response to the Three Mile Island plant failure), Shelor et al. (1990) and Shelor et al. (1992) (both examining market reactions to the 1989 California earthquake), Lamb (1995) (studying market reactions to Hurricane Andrew), Cummins and Lewis (2003) and Carter and Simkins (2004) (examining market effects of the Sept. 11, 2001 terrorist attacks) are all examples of this kind of work. Such studies provide valuable insight on market behavior of particularly important rare events. However, the unique nature of the events studied can make it difficult to generalize the results to other “catastrophic” events.

A second broad category of market reaction studies of catastrophic events tends to rely on some form of event study. These studies examine market reaction to more frequent catastrophic events. An example of this sort includes Worthington and Valadkhani (2004), who use intervention analysis to examine Australian market reaction to several forms of disaster, including tropical cyclones, concluding that cyclones affect the market with a lag. Other good examples include Rothwell (1989), who examines market reactions to nuclear reactor failures, Sah et al. (2008), who find that Real Estate Investment Trusts do not exhibit abnormal returns from hurricane events, and Capelle-Blancard

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[1] See http://www.nhc.noaa.gov/verification/verify5.shtml. In line with this improvement, Willoughby (2005) demonstrates that hurricane characteristics can now be predicted well enough to predict economic effects via RAINEX simulations.

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and Laguna (2010) who find that chemical companies decline in value in response to industrial disasters.

Our study does not fall neatly into either category, though it has more in common with the second. Unlike research on market reactions into disasters such as terrorism, earthquakes, and chemical spills, we have the benefit of high-quality forecasts of a particular form of potential disaster — hurricanes. In such an environment, market participants may be expected to behave not at the moment the disaster strikes, but in anticipation of the event as a result of the publicly available forecasts. This has been verified in previous research.

However, previous research has not examined the implications of the improved accuracy of NHC forecasts on the sizable energy markets that incorporate weather information into valuation. To what extent have the market reactions to NHC forecasts changed through time? Do market participants regard the improved forecast accuracy as a reliable enough improvement to change their behavior? We aim to answer these questions in a more comprehensive way than has been attempted previously. Specifically, we model changes in investor information sets by examining revisions in NHC forecasts, following Fink et al. (2010). We isolate our attention to a particular geographic region — the northwest Gulf of Mexico. We impose this restriction because a significant plurality of the petroleum refining capacity of the United States is concentrated in this coastal region. We then test the relationship of these storm forecast revisions to the returns of an index of petroleum refining firms. We examine two decades of market reactions to storms, and find that as NHC hurricane track forecasts improve, prices react earlier to the forecasts. Equity prices of petroleum refining firms appear to react to tropical storms a full 24 h earlier in the 2000s than they did in the 1990s, though the magnitude of the reaction remains the same.

Our study is made possible by the limited geographic diversification of the refined petroleum industry in the United States. This geographic concentration may be seen by examining the Petroleum Administration for Defense Districts (PADD) that were created as an organizational notion by the U.S. War Department during World War II. Five districts were created; the Gulf coast region was given the designation of PADD III. PADD III is comprised by the states of Alabama, Arkansas, Louisiana, Mississippi, New Mexico and Texas and as of December 2009 contains 47.7% of distillation capacity in the United States.[2] Most of the gasoline in the United States is refined in PADD III.[3] PADD III contains the ports of South Louisiana, Houston, Beaumont, and New Orleans — four of the seven largest ports in the United States by cargo volume.[4] Proximity to these ports allows refineries in this region to obtain crude oil from the Gulf coast continental shelf and throughout the world (see Andrews et al. (2010)). Proximity to these ports also explains the relative lack of geographical diversification evident in this industry. Further, PADD III is also crossed by the Colonial pipeline, a 5500 mile pipeline that connects Gulf coast refineries to the southeastern United States and up to New York harbor.[5] This pipeline is used to transport refined petroleum products to distant population centers. Interestingly, tank-barge operators and national maritime unions protested federal subsidies for the construction of pipelines, in an effort to preserve jobs (see Parker and Hood, 2002). These political activities likely contributed to the already natural concentration of the industry.

The geographic concentration of the refining industry gives us a natural avenue to test market reactions to hurricane forecasts. The improvement in NHC forecasts and the corresponding changes in market behavior are directly important to the petroleum refining industry — an industry with over $709 billion in revenues in 2011.[6] The forecasts appear to be particularly important to investors in the larger firms that comprise this industry. Increased threats from tropical storms appear to have the effect of increasing the returns to these firms. We find, for example, that in the 2000s, the presence of a category 4 hurricane in the northwest Gulf of Mexico, where previously there had been none, results in an approximately 1% increase in the return to large firms. This return increase creates about $8 billion in value for large diversified firms in the industry. Small firms experience no corresponding increase. This difference in the return to large versus small firms appears to reflect the benefit of geographic diversification, and the ability to convert idle capacity to production in order to capitalize on higher refined petroleum prices after the passage of the storm.[7]

2. Data and variable construction

2.1. Tropical storm data

Our study draws on data from several sources. We collect our storm data from the National Hurricane Center's Automated Tropical Cyclone Forecast (ATCF) archive data files.[8] This dataset includes information on all tropical depressions, tropical storms and hurricanes in the Atlantic basin, including the Caribbean and the Gulf of Mexico. It provides the official real-time estimates of the latitude, longitude, and wind speed for each storm tracked by the NHC. These estimates are available every 6 h for the life of the storm. Further, the ATCF records the NHC official latitude, longitude, and wind speed forecast estimates for those six hour intervals — the estimates announced publicly at these regular intervals and reported by a wide variety of media outlets. Different forecast horizons are provided for different time periods, as the NHC has modified its forecast packages through time. One notable limitation is that 96-hour and longer forecasts are not available prior to 2001. We therefore limit our use of the data to a 72-hour forecast window.[9] The time period covered by our storm data is January 1, 1990 to Dec. 31, 2009.[10]

The ATCF provides real-time official forecast data for 0000, 0600, 1200 and 1800 Greenwich Mean Time (GMT) every day for the life of an Atlantic Basin storm. 1800 GMT corresponds to the final daily data release during open U.S. equity market hours, corresponding to 1:00 or 2:00 PM Eastern Time, depending on whether the U.S. is in daylight savings time. We therefore use the 1800 GMT forecast data to construct our weather-related forecast variables each day. Specifically, we employ the 24-, 48- and 72-hour forecast horizon information, as well as information about the current state of the storm. The measure for the severity of storms comes from the wind speed definitions in the Saffir–Simpson scale, extended to include tropical depressions and tropical storms. This scale is presented in Table 1.

We define our region of interest loosely as the portion of the PADD III district that abuts the northwestern Gulf of Mexico. Damaging storms in this region have significant effects on refined energy prices and the profitability of refining firms, as approximated by futures prices such

[2] See http://tonto.eia.doe.gov/dnav/pet/PET_PNP_UNC_DCU_R30_M.htm and http://tonto.eia.doe.gov/dnav/pet/pet_pnp_unc_dcu_nus_m.htm, both web sites maintained by the Energy Information Administration.

[3] See Andrews et al. (2010) p. 2 – 12 for detailed background on the distribution of petroleum refineries, as well as some history of the industry.

[4] See the American Association of Port Authorities statistics for 2010, available at: http://aapa.files.cms-plus.com/Statistics/2010%20U.S.%20PORT%20RANKINGS%20BY%20CARGO%20TONNAGE.pdf.

[5] For a fascinating look at the development of this pipeline in the 1960s, see Comstock (1963) beginning on p. 130.

[6] See Considine et al. (2004) for an adaption of a cost-loss model to estimate hurricane forecast value to the oil and gas industry. Revenue data is from Yang (2012).

[7] There is an extensive literature on the transmission of refined petroleum prices from the wholesale to the retail levels. See, for example Borenstein et al. (1997), Bachmeier and Griffen (2003), Chen et al. (2005) and Lewis and Noel (2011).

[8] See Sampson and Schrader (2000) for a review of the ATCF dataset.

[9] For a detailed discussion of hurricane forecast accuracy, see Franklin (2010).

[10] ATCF provides 24-, 48- and 72- hour official NHC forecasts for all storms tracked by the NHC over this time period. Official time zero intensity and location estimates are not provided in this dataset prior to 2001. Following Fink et al. (2010), for 1990 – 2000, we use the Combined Automated Response to Query (CARQ) data, included in the ATCF, for this information. CARQ is the real-time model input for the forecast algorithms used by the NHC, and therefore reflects the best publicly available information of time zero location and intensity.