# Shocks and Stocks: A Bottom-up Assessment of the Relationship Between Oil Prices, Gasoline Prices and the Returns of Chinese Firms

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**ABSTRACT**

Oil price shocks are known to affect the financial sector of the economy, due to the inflationary effects, and increasing costs of doing business they create. Though oil-shocks and financial markets are widely researched, there remains scope for deeper understanding using firm level data. We therefore contribute to the literature by extending widely applied multi-factor asset pricing models to a sample of 963 Chinese firms (between 2005–2013) to (i) systematically evaluate their reactions to oil price shocks, and (ii) further include regulated gasoline prices as a more direct measure of the energy-prices faced by firms. 89.2% of firms are susceptible to oil shocks, with positive and negative reactions observed even for firms within the same industry. Gasoline price shocks are more pervasive, affecting 95.7% of firms. Considering oil and gasoline separately allows us to review gasoline price regulation in China, which ultimately appears ineffective in achieving its intended goals.

**Keywords:** China, Financial markets, Oil price shocks, Gasoline price shocks, Firm-level

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## 1. INTRODUCTION

China is one of the largest net importers of oil in the world. Consumption levels are growing at a tremendous pace, with a year-on-year average growth in oil consumption of 6.3% between 2000–2013. At the same time the import dependency of the nation is also increasing: domestic production accounted for 68.3% of consumption in 2000, but by 2013 this had fallen dramatically to just 38.9%. Accordingly, shocks[1] in the international price of oil cannot be avoided by the Chinese economy. Many existing studies have sought to document what consequences such price shocks have upon the various parts of an economy, with a growing body of literature specif-

1. In this paper we use the simpler definition of shocks based on the growth of prices, that has been adopted quite widely in the literature. We are however aware that alternative definitions are discussed in the literature also, that in simple terms attempt to separate expected price movements from unexpected ones, treating the latter as a more refined measure of price shocks. Kilian (2015) provides a succinct but informative summary of the main differences between these approaches.

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ically considering the Chinese context. Results are inevitably mixed, for example: Broadstock and Filis (2014) and Fang and You (2014) show that the source of oil shock can lead to different signs of effect; Broadstock and Filis (2014) further argue effects are positive in some periods and negative in others; and Wen et al. (2014) suggest effects may be negative in the short run and positive in the long run. Together, these facts, along with a simple understanding of the scale of China, comprising a population well in excess of a billion people with rapidly growing wealth, create an imperative to study this economy. Further, China is in a unique stage of transformation and economic development, global oil prices continue to boom and bust, as do the Chinese financial markets: factors all of which create an urgency to develop an up-to-date, innovative and detailed understanding of how international oil prices pass through to the domestic economy.

There are several routes by which energy price shocks can exert an influence on the economy. Brown and Yucel (2002), review the various transmission mechanisms that have been presented in the literature. The identified channels include impacts on the costs of production (supply side effects) and downstream inflationary pressures (both wages and general prices) that these may instill. Reactions to sudden energy price shocks have been shown by some to alter the demand for money, and create incentives for monetary authorities to revise monetary policy (real balance effects). Other effects to manifest include rebalancing of the industrial structure mix that can result from changing costs of production, and other 'unexpected' effects attributed to energy price uncertainty. All of these channels have ramifications that manifest in fluctuations of financial markets, and for decades economies have paid close attention to energy price changes, oil prices in particular.

Narayan and Sharma (2011) and more recently Phan et al. (2015a) discuss in reasonable detail how energy price shocks can plausibly result in either positive or negative effects on firm returns.[2] These effects can arise due to trade-offs between risk and return, the potential to hedge spot and future contracts, inflationary effects and wider general equilibrium effects. The unique reaction to price changes by specific firms will vary for a number of reasons, including internal managerial processes, the regulations and governance structures that may exist for the industry as well as (and perhaps most importantly) the choices and behaviors of investors. Narayan and Sharma (2011) made an initial effort to characterize the nature of firm specific reactions, by considering the impact of oil price changes upon stock value changes (i.e. market returns) separately for 560 US firms. Their results intuitively reveal substantial differences in the types of firms which are affected, how quickly they react to oil price changes, and how their resilience may vary in line with factors such as firm size.

The body of literature which Narayan and Sharma (2011) is a part of is heavily grounded within the financial economic literature, where questions regarding the reaction of stock markets to commodity prices are commonplace, (see for example Ciner (2012), Nguyen and Bhatti (2012), Driespong et al. (2008) and Jones and Kaul (1996) among many others). In this context oil prices are used as a general measure of energy price risk exposure—a measure which is freely available and obtainable in high-frequency (e.g. observed daily) making it convenient for comparing against stock market data. Oil prices have proved a valuable indicator in this area of research, however as for example Smith (2009) remarks, "*. . .[the] demand for crude oil is a derived demand that stems from the demand for gasoline. . .*", a point which is generally taken for granted as common knowl-

2. Narayan and Sharma (2011) do acknowledge the empirical tendency for effects to be negative e.g., a positive price shock will adversely impact economic outcomes. It is also worth noting a more recent study (Narayan and Sharma, 2014) which also demonstrates that returns volatility is also susceptible to oil shocks. Lastly, Phan et al. (2015b) use predictive regressions to illustrate that oil prices can be used to help improve stock price forecast accuracy.

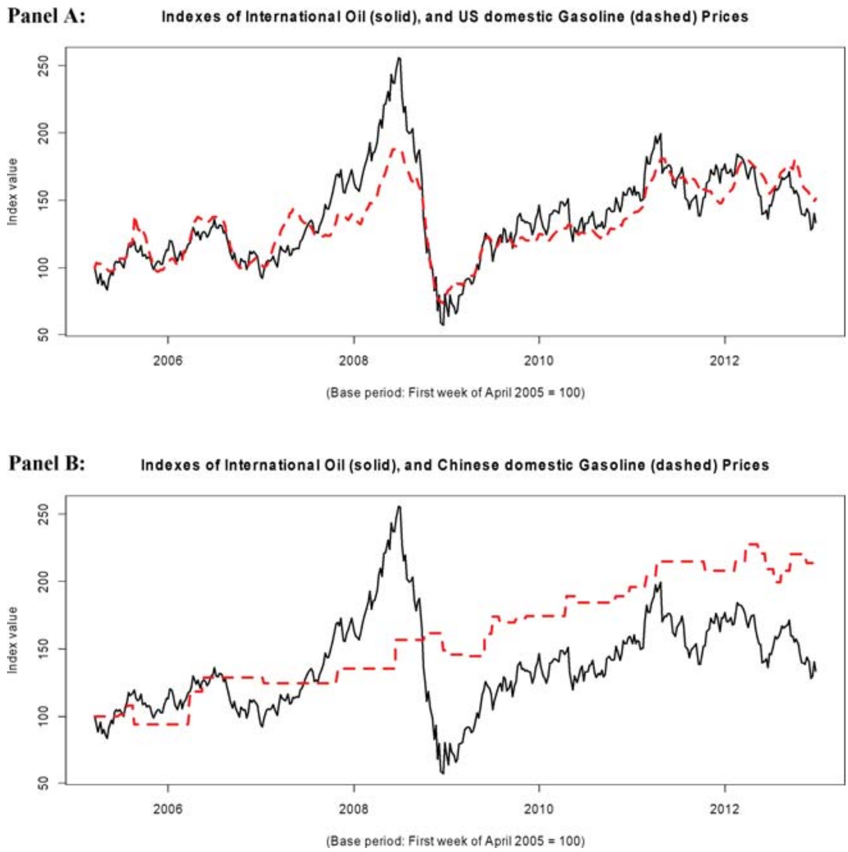
edge among energy economists but admittedly one which is easily overlooked—even by energy economists. Gasoline is of relevance to all firms as a consequence of the unavoidable requirement for transportation services—either directly for delivery of goods and services, or indirectly to support the travel of workers to and from the workplace—hence gasoline price shocks are more directly relevant than oil prices to the cost performance (and hence financial value of) firms. Moreover very few firms require oil as an intermediate input into their production supply chain in any scale (notwithstanding for instance lubrication liquids for machines etc.), which implies reactions to gasoline shocks would likely be more prevalent than reactions to oil shocks.

This issue has not however been considered within previous related literature e.g. the literature connecting energy prices to company stock returns, and so the extent to which this might be considered a limitation, concern or deficiency of the existing literature must be given due and fair consideration. Reviewing some of the facts as we know them, beyond transformation for gasoline, oil has a rather limited range of uses, which results in a naturally high degree of correlation between oil and gasoline markets. In markets/countries where gasoline prices are absent of strong regulations, such as in the US, it can be seen that the degree of association between oil and gasoline prices is very high (see Figure 1, Panel A), with a correlation of 0.87 between 2005–2012. Conversely in an economy like China, which is still in the process of marketization, and where there remains a high degree of price regulation for gasoline—discussed in further detail below—which serves to mediate the speed and extent to which international oil price changes pass through to gasoline prices (see Figure 1, Panel A) there may exist a much weaker correlation between oil and gasoline, 0.46 between 2005–2012 in the case of China. Accordingly for studies concentrating on markets like the US, including Narayan and Sharma (2011) among many others, the high degree of correlation between oil and gasoline, including gasoline prices would be unlikely to result in largely different insights, but probably generate some statistical problems increasing the estimation complexity. For China on the other hand, since oil and gasoline follow clearly different trends, additional insights may well emerge. It is reasonable to imagine that (i) the reactions to oil price shocks and gasoline price shocks should not be the same; and further posit that (ii) under the assumption that gasoline prices are regulated for the purpose of reducing the extent of risk exposure to oil price movements, then when regulation exists, oil shocks should be much less likely to impact stock returns; and lastly that (iii) given the specific nature of the Chinese gasoline price regulation mechanism, that price changes should be predictable and their effects more easily managed than if the regulation was absent. To paraphrase the above, this line of questioning is of special relevance in countries where gasoline price regulation mechanisms are being adopted.

This study closely follows the line of research presented by Narayan and Sharma (2011)[3] inasmuch as it makes a comprehensive bottom-up assessment of the relationship between energy price shocks and the financial returns of 963 Chinese listed firms. The aims of the work are to discern, from the highly computational exercise, a more concrete understanding of where, when and how oil prices pass through to Chinese firms. The first, and more general of the two empirical contributions is to explicitly test the hypothesis that, in addition to oil price shocks, gasoline price shocks impact firm financial performance, modelled in the context of a general asset pricing model of the capital asset pricing model (CAPM) type. From this stems two natural sub-questions including (i) whether the firms/industries impacted by oil shocks are the same as those affected by gasoline

3. We adopt in spirit the main method of Narayan and Sharma (2011), but acknowledge they also include analysis on size effects using stock turnover data, which we do not use here. This could be an interesting and useful extension for future study.

**Figure 1: International Oil Price (solid black line), based on U.S. West Texas Intermediate Oil, relative to: Panel A: the U.S. Domestic Unregulated Regular Conventional Retail Gasoline Price; and Panel B: the Domestic Regulated Gasoline Price (dashed red line), based on the Beijing Price for RON 93 Grade Fuel**




*Note:* All series are re-based with the first observation set equal to 100 to ease comparison.

price shocks and/or (ii) whether the size of reaction to a gasoline price shock is the same as the size of reaction to an oil price shock—intuitively there should be some important differences. The second contribution stems from the application of the bottom-up approach of Narayan and Sharma (2011) to a different market context, with our empirical sample being from the still developing Chinese economy, as opposed to the developed market economy context of the US, and also covering a larger sample of firms, increasing the confidence in the conclusions drawn. Also, the presence of gasoline price regulation in China allows for potentially different insights to be revealed compared with for example the US.

Our results offer a comprehensive understanding of the relationship between energy price shocks and stocks of different types in China, with lessons that are very clearly generalizable to other international contexts. The primary result is that, in the long-run, oil price shocks have some impact, either positive or negative, on the asset returns of 89.2% of firms. Gasoline price shocks are even more widespread, affecting the financial outcomes of 95.7% of firms. There is no clear evidence that the firms most severely impacted by oil shocks are the same ones that are most severely affected by gasoline price shocks. This broadly reinforces the adopted intuition that gasoline price shocks are more relevant to the financial performance of firms than oil price shocks. There is a marked difference of the number of firms affected in the short run compared with the long run. In the short run only 25.5% of firms react to oil-shocks, and 39.5% to gasoline price shocks. Reactions to gasoline shocks are still more prevalent in the short run than reactions to oil shocks, but more importantly only a fraction of firms have a short-run reaction compared to the number that have a long-run reaction. This illustrates that financial markets are inefficient when it comes to valuing the impact of energy price changes, since an efficient financial market processes all news immediately.

Several additional results are also reported and discussed. We note that while the estimations are resolved at the firm level, for pragmatic reasons the results are generally discussed at the industry level, but stress that industry insights based upon firm level estimates allow detailed insights regarding the within-industry effects to be revealed and highlighted. These insights would not otherwise be observed using industry portfolios. Some key findings are as follows: We document strong evidence in support of asymmetric firm level responses to energy price rises and energy price falls e.g. that the returns of a firm will react differently to price rises than to price falls; The sign of reaction to any given price change (e.g. a rise in the price of oil) varies across firms, and can be either positive or negative—even for firms within the same industry—which reveals that industry level analyses are likely to be prone to aggregation biases that may inappropriately suggest statistical insignificance; At the level of the firm it cannot be concluded that reactions to oil or gasoline price shocks is meaningfully correlated with energy intensity—which may suggest that more energy intensive industries are better placed to manage risk from (i.e. forcibly become less/in-sensitive to) changing oil and gasoline prices; lastly, structural breaks are controlled for, allowing for coefficients, and hence reactions to energy price changes, to differ across sub-samples of the data—from this we learn that the returns of any given firm may be negative, positive or insignificant during different periods of the sample (and for 79 out of the 963 firms, the different sub-samples include all three possible effects).

The paper proceeds with a short literature review, describing the state of understanding on how oil shocks and gasoline prices impact firm value. After this the data and methodology are presented, setting out a systematic and pragmatic estimation procedure that will reveal firm-specific reactions to general market risk, regulated gasoline price changes and oil price shocks with controls for structural instability and asymmetric price response functions. The following section summarizes the main results, focusing largely on the distributions of all shocks which firms/industries are affected, when, are these effects asymmetric, and are regulated prices (i) having a smaller impact than international oil prices and therefore (ii) is the regulation system achieving its intended goals. General discussion and policy implications are drawn in a separate section before the paper is concluded.

## 2. REVIEW OF THE LITERATURE

There has, over the years, been a wealth of studies looking into a multitude of features covering the nexus of energy prices and financial markets. This section revisits only a selection of the most important contributions offered by the previous literature. Inevitably the review is not able to be comprehensive, owing to the sheer volume of related works.

It is useful to revisit the contributions of the first major study on energy prices and the economy, which among other things set an early benchmark for the general features that need to be considered in any empirical study on oil. The earliest major econometric study was Hamilton (1983), who demonstrated that oil shocks co-moved with changes in economy wide activity e.g.

growth in gross domestic product. The proposed model, though simple, illustrated that most periods of recession in the US were in some manner influenced by oil price movements. The results were challenged by Hooker (1996), claiming that the evidence in support of Hamilton's claims that oil shocks caused recessions was not sufficiently convincing, and could even be disproved. Hamilton (1996) responded with an innovative application of econometrics that combined concepts of regime switching with asymmetric variable decompositions and rebutted Hooker's arguments with emphatic evidence that his previous claims were not merely incidental.

The early contributions of Hamilton (1983, 1985) confidently established the connection between oil and the economy (i.e. set the foundation for the stylized fact that oil prices matter), further studies on this and related topics have become a mainstay in the energy economic literature. Hamilton's contributions paved the foundations for the model features which still guide even the most recent studies: First is that the relationship between oil and the economy is not a fixed one, and may be stronger in certain periods than it is in others; Second is that the reaction to price rises and price falls are very likely to be different due to habit formation combined with rapid and exuberant reactions to price falls; Lastly is the concept that maybe not all price changes matter, and certain price changes may effectively be too negligible to care about.

There is a long literature on the relationship between oil prices and financial markets, summarized in Table 1. Early references considering how financial markets react to movements in oil prices include Huang et al. (1996) who showed that crude oil futures impact oil company stock returns, but do not affect some other industries. The general conclusion, more concisely discussed by Gogineni (2010), is that the energy consumption structure of industries helps describe where oil shocks matter, the more oil intensive an industry the more likely it will depend on oil shocks. When industries are broadly classified into oil-intensive and non-oil intensive groups the influence of oil price shocks on stock returns is more readily discerned from existing studies. Some of the many studies in recent years that consider individual industry sectors include: Broadstock and Filis (2014); Narayan and Sharma (2014); Zhang and Cao. (2013); Scholtens and Yurtsever (2012); Arouri (2011b); Broadstock et al. (2012); Narayan and Sharma (2011); Arouri (2011a); Elyasiani et al. (2011); Mohanty et al. (2011); Arouri and Nguyen (2010); Kilian and Park (2009); Nandha and Faff (2008); Boyer and Filion (2007); El-Sharif et al. (2005) and Hammoudeh and Li (2005). Across these studies the general finding is that the Oil & Gas sector, and also the Mining sector, tends to be positively affected by rising oil prices, whereas for other sectors it is more likely to be negative. It is worth adding, as can be seen from Table (1), that there are a wide range of methodologies employed in this literature, including methods that account for endogeneity and causality (VAR/SVAR), time varying effects (regime switching), high-frequency and volatile data (GARCH, and also BEKK/DCC for dynamic correlation assessment), and non-linear effects. The differing methods can also be a source of differing conclusions.

A larger body of literature looks at aggregate stock indexes rather than industry/sector specific ones. These studies tend to find a negative relationship between oil shocks and the performance/returns of whole stock markets (see, inter alia, Narayan and Gupta (2015), Filis and Chatziantoniou (2014); Ciner (2012); Lee and Chiou (2011); Zhu et al. (2011); Filis (2010); Chen (2010); Miller and Ratti (2009); Driesprong et al. (2008); Nandha and Faff (2008); O'Neill et al. (2008); Park and Ratti (2008); Bachmeier (2008); Henriques and Sadorsky (2008); Sadorsky (2001); Papapetrou (2001); Ciner (2001); Gjerde and Saetten (1999); Huang et al. (1996); Jones and Kaul (1996)).

The influence of oil price shocks on emerging market stock prices has only become a focus of study in more recent years. Different from the relatively consistent results found in developed

**Table 1: Related Studies on the Relationship Between Oil Prices/Shocks and Financial Markets**

| Country | Methodology | Period | Stock index | Authors | Broad findings on effect of oil shocks* |
|---|---|---|---|---|---|
| U.S. | VAR | 1983–1990; | Aggregate, industrial and specific firm stock prices | Huang et al, 1996 | Focus on futures, find effect only for oil companies |
| U.S. | Regression | 1986–2007 | Industrial stock indices | Gogineni, 2010 | Positive and negative effects on US stocks, varying by industry and time period. |
| U.S. | GARCH | 2000–2008; | US stocks; | Narayan and Sharma, 2011; Narayan and Sharma, 2014 | (Narayan and Sharma, 2011) Mix of positive and negative effects of oil price growth on US stock returns; (Narayan and Sharma, 2014) Mix of positive and negative effects of oil price growth on US stock volatility. |
| | | 1998–2006 | Thirteen U.S. industries | Elyasiani et al., 2011 | (Elyasiani et al., 2011) Mixed positive and negative effects varying by industry |
| U.S. | Regression, Granger causality | 1986–2010; | Aggregate and individual stock indices | Ciner, 2001 | (Ciner 2001) Indeterminate sign, nonlinear causality; |
| | | 1986–2003 | | Bachmeier, 2008 | (Bachmeier, 2008) Asymmetric and generally negative effects on stock returns. |
| U.S. | Regression, Markov regime-switching, ARMA-GARCH | 1992–2008; 1957–2009; | S&P 500 | Chen, 2010; Lee and Chiou, 2011; | (Chen, 2010) Rising oil prices lead to more bearish markets; (Lee and Chiou, 2011) When price volatility is high, price shocks negatively affect stock returns; (Narayan and Gupta, 2015) Asymmetric lagged effects, with stronger reaction to price falls. |
| | | 1859–2013 | | Narayan and Gupta, 2015 | |
| U.S. and China | SVAR, Scalar-BEKK | 1995–2013 | Aggregate and industrial stock indices | Broadstock and Filis, 2014 | Mix of positive and negative correlations, varying by time period, industry and source of oil shock. |
| U.S., Mexico and Norway | Cointegration and dynamic causality | 1986–2003 | four oil-sensitive stock indices | Hammoudeh and Li, 2005 | Oil futures positively affect oil-sensitive markets, but negatively affect the world market. |

*(continued)*

**Table 1: Related Studies on the Relationship Between Oil Prices/Shocks and Financial Markets** *(continued)*

| Country | Methodology | Period | Stock index | Authors | Broad findings on effect of oil shocks* |
|---|---|---|---|---|---|
| U.S. and Europe | SVAR, VAR | 1986–2005; 1973–2006 | Country-level stock indices | Park and Ratti, 2008; Kilian and Park, 2009 | (Park and Ratti, 2008) Mix of positive and negative impulses responses; (Kilian and Park, 2009) Positive and negative effects, varying by industry and source of oil shock. |
| Europe | Dynamic VAR | 1983–2007 | Industrial stock indices | Scholtens and Yurtsever, 2012 | Mix of positive and negative effects varying by industry. |
| Europe | GARCH types, regression | 1998–2010 | Twelve sector indices | Arouri and Nguyen, 2010; Arouri, 2011a; Arouri, 2011b | (Arouri and Nguyen, 2010) Positive and negative effects varying by sector and econometric assumptions (Arouri, 2011a, 2011b) Asymmetric effects to price rises and price falls, varying by sector for weekly data. |
| Greece, Norway | VAR | 1989–1999; | Aggregate stock indices | Gjerde and Saetten, 1999; | (Gjerde and Saetten, 1999) Positive covariance between oil price changes and real stock returns, but no causality |
| | | 1974–1994; | | Papapetrou, 2001; | (Papapetrou, 2001) A positive oil shock depresses real stock returns |
| | | 1996–2008 | | Filis, 2010 | (Filis, 2010) Oil prices negatively impact the Greek stock market. |
| Canada | Multifactor model | 1995–1998, 2000–2002; | 105 oil and gas corporations | Boyer and Filion, 2007 | (Boyer and Filion, 2007) Generally positive influence on stocks of oil and gas companies |
| | | 1983–1999 | | Sadorsky, 2001 | (Sadorsky, 2001) Positive impact on oil-related stocks. |
| UK | Multifactor model | 1989–2001 | Oil and Gas sector index | El-Sharif et al., 2005 | Positive effect on UK |
| GCC countries | Regression | 2005–2009 | Country-level, industry-level stock indices | Mohanty et al., 2011 | Generally positive impact of oil price shocks on stock returns at country and industry level (12/20 industries) |

*(continued)*

**Table 1: Related Studies on the Relationship Between Oil Prices/Shocks and Financial Markets** *(continued)*

| Country | Methodology | Period | Stock index | Authors | Broad findings on effect of oil shocks* |
|---|---|---|---|---|---|
| World | Market model; VAR | 1983–2005; | 35 global industry indices; | Nandha and Faff, 2008 | (Nandha and Faff, 2008) Generally negative impact across sectors, except for positive impact upon mining and oil & gas; |

| | | | | | |
|---|---|---|---|---|---|
| | | 2001–2007 | clean Energy Index and technology stock indices | Henriques and Sadorsky, 2008 | (Henriques and Sadorsky, 2008) Negative impact on technology stocks, but no impact on alternative energy stocks. |
| OECD countries | VECM, Regression | 1971–2008; 1947–1991 | Country-level stock indices | Jones and Kaul, 1996; Driesprong et al., 2008; Miller and Ratti, 2009 | (Jones and Kaul, 1996) Negative effect of oil price changes; (Driespong et al., 2008) Oil price rises lower future stock returns; (Miller and Ratti, 2009) Initially negative relationship that eventually disappears at the end of the sample. |
| 14 OECD and non-OECD countries | Panel cointegration | 1995–2009 | Country-level stock indices | Zhu et al,, 2011 | Asymmetric effects, varying between the short run and the long run. |
| Oil exporting and importing countries | SVAR | 1999–2011; | Country-level stock indices | Wang et al., 2013; | (Wang et al., 2013) Mix of positive and negative nonlinear causality varying by country and source of oil shock.; |
| | | 1991–2010 | | Filis and Chatziantoniou, 2013 | (Filis and Chatziantoniou, 2014) Positive effect for oil exporters and negative effect for oil importers. |
| Emerging market countries | Multifactor model; CAPM; GARCH | 1992–2005; | Country-level stock indices | Basher and Sadorsky, 2006; | (Basher and Sadorsky, 2006) Positive impact on emerging economies stock returns; |
| | | 1997–2007; | | Aloui et al., 2012; | (Aloui et al., 2012) Positive/negative depending on bullishness of markets; |
| | | 2000–2012 | | Sadorsky, 2014 | (Sadorsky, 2014) Negative conditional correlation of oil price changes with emerging market stock returns, becoming positive after 2008. |

*(continued)*

**Table 1: Related Studies on the Relationship Between Oil Prices/Shocks and Financial Markets** *(continued)*

| Country | Methodology | Period | Stock index | Authors | Broad findings on effect of oil shocks* |
|---|---|---|---|---|---|
| Asia-Pacific region | Copula model; AR-GARCH | 2000–2012 | Country-level stock indices | Zhu et al., 2014 | Generally positive impact on Asia-Pacific stock indices, strengthening after 2008. |
| China | GARCH, CAPM | 2000–2011 | Energy related stock price indices | Broadstock et al., 2012 | Positive effect on energy related stocks, strengthening after 2008. |
| China | GARCH, CAPM | 1997–2011 | 13 major sectors | Zhang and Cao, 2013 | Only the mining sector and `general’ sector are affected, reacting positively to an oil price change. |

| | | | | | |
|---|---|---|---|---|---|
| China | VAR | 1996–2007 | Aggregate, industrial and specific firm stock prices | Cong et al., 2008 | Mostly insignificant effects except negative impact on oil stocks, and positive impacts on manufacturing/mining and petrochemicals. |
| China | BEKK GARCH | 2006–2012 | New energy/fossil fuel stock indices | Wen et al., 2014 | Negative news on fossil fuel stocks leads to an increase in new-energy stock returns. |
| China | Panel cointegration | 2001–2010 | 13 major sectors | Li et al., 2012 | Negative short run and positive long run effect on stocks. |
| China, India, Russia | SVAR | 2001–2012 | Country-level stock indices | Fang and You, 2014 | Mixed effects varying by source of oil shock and country. |
| China and Vietnam | Copula | 2000–2009 | Country-level stock indices | Nguyen and Bhatti, 2012 | Positive effect on Vietnam; No effect on China. |

*Notes:* * These "Broad findings" are a very summary overview of the papers conclusions regarding the role of oil shocks. Each paper is highly detailed, adopting differing methods, with different datasets over different time periods etc. The various conclusions cover linear and non-linear effects, long- and short-run effects, Granger causality evaluations, differing definitions of oil shocks etc. The purpose of this table therefore is to highlight the breadth of work being done, and offer supplementary evidence that mixed conclusions (regarding sign of effect) are already documented in the extant literature.

countries, the findings on the relationship between oil prices and emerging market stock returns are more mixed. Some studies find a positive relationship between oil prices and emerging market stock returns (Zhu et al. (2014); Sadorsky (2014)), while Nguyen and Bhatti (2012) and Aloui et al (2012) find that oil prices do not exert any significant impact on emerging market stock returns. Basher and Sadorsky (2006) claim that the relationship depends somewhat on the data frequency used: Oil price increases have a positive impact on stock market returns for daily and monthly data; while oil price decreases have positive and significant impacts for monthly data in emerging markets.

A relatively smaller body of literature has been dedicated to the impact of oil shocks on Chinese stocks. There are reasons for this including the fact that oil was not a major concern until recent years when China became a net oil importer. Further, China's financial markets are relatively young, having only been established in the 1990's. Today though there is rich financial market data, and an ever increasing desire to know the consequences of oil price changes, which cumulatively increase the need for ability to do insightful research. There is a general gap in the understanding of how oil shocks, or indeed gasoline price shocks, impact the financial value of Chinese stocks/firms.

Cong et al. (2008) look across a range of industries including manufacturing, mining and pharmaceuticals among several others. Their results are convincing and give much needed detail on industry specific reactions to oil shocks, though they also suggest that the aggregated results need to be complemented with more micro level analysis in order to better reveal the mechanisms that underlie them. Wen et al (2014) model spillovers between new energy and fossil fuel stock returns, finding evidence of significant asymmetric effects. Fang and You (2014) find oil price changes driven by global oil demand shocks have no significant effect, while demand-driven shocks generate a significant lagged negative effect. Li et al. (2012) focus on the causal relationships between oil shocks and stock returns in China, controlling for multiple structural breaks. While their analysis uses sector specific data their method generally aggregates over the sectors. Their ultimate conclusion is that "*There is clear evidence that increased oil price has a positive impact on sectoral stocks in the long run*.", pp. 1957, which by their own admission is inconsistent with theoretical expectations. This leads them to conclude ". . . *Chinese stocks may be an attractive destination for hedging hikes in oil prices*." pp. 1957. Given the heavy and constantly growing oil import dependency of China, these conclusions seem a little difficult to accept as applying to the whole economy. All previous research focusing on Chinese stocks, use either sector specific or whole market stock indices, but as far as is known there are no firm level assessments for China present in the literature to date.

In light of the wealth of literature that exists, it is fair to say that many intricate aspects have been explored. The underlying sentiment of the literature does not however appear to be one of clarity. Arguably the growing body of literature is losing some focus with authors trying to challenge each other on the validity of differing conclusions which are arising from differing datasets over differing sample periods, using differing methods and so forth.

## 2.1 Implied Gaps and Research Objectives

Given the existing literature there are three core gaps: first is a lack of study of data at the firm-level; second is a lack of consideration of gasoline prices; third is a general lack of empirical evidence on the Chinese context. The next two sections describe the data and methodology we use to tackle these gaps. To help structure the discussion and analysis that will follow towards policy relevant outcomes, several research questions/objectives are offered:

- How does the financial performance of a firm respond to an oil shock? Do firms react the same way to price rises and falls, in the short run and the long run?
- Do firms react to gasoline prices at all, and if so are their reactions the same (or at least similar) as those to oil price shocks?
- Which types of industry/firms are affected more than others?
- What is the relationship between the scale of reaction to oil/gasoline prices and the energy intensity of an industry?

Answering the above questions, though not necessarily in exactly the same order, will be the focus of the remainder of the paper and will deliver important insights that should help to reconcile existing related literature and also provide a substantial amount of evidence that can be used to review existing pricing policies in China, and help to advise on future refinements.

## 3. DATA

The data used in this paper are weekly frequency ranging from the first week of April 2005 to the last week of December in 2012. The Shanghai composite stock index, data on international oil (West Texas Intermediate)[4] price and Chinese domestic gasoline prices (China State Guidance Retail 93 RON gasoline price for Beijing), exchange rates, and also the firm level stock return data are all taken from the Bloomberg financial database. The list of members is based on the membership in January 2014 giving a potential of 994 individual firms. In the estimation work summarized below, 31 of these firms have either too short samples, or fail to converge, resulting in 963 firms being included in the final dataset. Additional market information on wider market factors, in particular the 'small-minus-big' (SMB) and 'high-minus-low' (HML) variables, are obtained from the Chinese RESSET financial database. SMB is the difference between firm with the smallest market capitalization and that with the largest, and therefore includes features relating to the size diversity in the market; HML measures the difference between the highest book-to-market ratio and the lowest, and is intended to reflect the balance of value-stocks versus growth-stocks in the market. Some additional data on industry level output and energy consumption, used later in the paper for comparisons of the results with the energy intensity of industries, are obtained from the Chinese National Bureau of Statistics online data sources.

The prices of oil and gasoline faced in China differ quite markedly, as was shown in Figure (1), Panel B. Certain differences are to be expected, since they relate to very different physical markets, with prices determined by different sets of suppliers and consumers, but the most notable feature in the domestic gasoline price comes in the clear role of regulation of market prices. There are many periods, particularly 2005–2009, where gasoline prices remain unchanged even when oil prices are changing quite markedly. While oil prices show clear periods of boom and bust, the gasoline price is much less volatile, and shows a much clearer pattern of increase between 2005–2012. Zhang et al. (2014) discuss the nature of gasoline price regulation in China, and the revisions to the price adjustment mechanism in recent years, in brief the mechanism is designed to allow domestic prices to adjust to changes in the underlying permanent component of international oil

4. We thank two anonymous referees for questioning the consequence of using the West Texas Intermediate price as opposed to either the Brent crude price, which reflects a larger share of international trade in oil, or the Chinese domestic crude oil price (Daqing). All results have been re-estimated using these alternative oil price measures, and although there are some inevitable quantitative differences, the overall qualitative conclusions of the paper remain robust to this choice.

prices, when such changes are excessive and sustained over several weeks. The mechanisms are unfortunately not fully transparent, since they ultimately provide a set of rules by which price revisions by the National Development and Reform Commission are admissible, but do not discuss the extent of price changes which are permissible. Accordingly markets can have an idea when to expect a price change, but less understanding of how much a change to expect.

## 4. METHODOLOGY

The methodological approach taken here is to devise an estimation algorithm (e.g. a common approach to modelling, testing and interpreting the models) that can be applied repeatedly to many hundreds of stock returns series and that will by construction eliminate the most obvious and severe complications of: missing data; structural instability; and time-varying heteroskedasticity (e.g. GARCH effects), which commonly appear when working with long financial time series.

Section 4.1 contains the general model specification, while 4.2 offers more detail in the econometric steps. Although Section 4.2 cannot be omitted, after reading Section 4.1 it is possible to skip to, and understand, the results section of the paper.

### 4.1 General Model Specification

We adopt an empirical asset pricing model specification that follows in the general spirit of Narayan and Sharma (2011) but with several important modifications. The foundation of the model is a capital asset pricing model (CAPM) type specification, which relates the (weekly) returns for the individual stock $R_{it}$, to the returns on the overall market index $RM_t$, in this case the returns on the Shanghai composite stock index. Broadstock et al. (2012), in a study looking into the impact of oil price shocks in the specific context of Chinese energy stock portfolios, show however that a Fama-French 3-factor specification is preferred to the simple CAPM specification for Chinese data. Thus two additional risk factors are introduced, namely $SMB_t$ and $HML_t$, which reflect wider structure characteristics of the financial market. Narayan and Sharma (2011) further control for exchange rates effects, $ER_t$, and so the Chinese RMB/US Dollar exchange rate is also included here to help delineate true energy price effects from general exchange rate related fluctuations.

Following Narayan and Sharma (2011), energy prices are then appended into the empirical asset pricing framework also. Specifically, Narayan and Sharma (2011) allow for the possibility that lagged energy price shocks can impact current period returns—thereby allowing short-run and long run effects to be separately identified, they apply an 8 day lag structure (analysing daily data), while on the other hand Kilian and Park (2009) use 24 months of lags (analysing monthly data). Balancing a desire to have a long lag-length against the need to maintain a reasonable number of degrees of freedom for estimation, a lag length of 8 weeks (or 2 months) is used here. Finally, numerous studies have advocated the importance of treating price rises and falls independently of each other. In this regard, and departing from the simpler oil price measure used in Narayan and Sharma (2011), the price decomposition introduced by Mork (1989) will be applied to oil prices, which separates oil prices into two parts, one which includes only price increases (taking the value zero when prices decrease) $Oil_t^{(+)}$, and another including only price decreases (similarly being zero when prices increase) $Oil_t^{(-)}$, with similar measures being applied to gasoline to give $Gasoline_t^{(+)}$, and $Gasoline_t^{(-)}$.

Putting all of the features mentioned in the previous two paragraphs together, the general empirical model for estimation can now be written as:

$$R_{it} = \gamma + \beta_R(RM_t) + \gamma_1(SMB_t) + \gamma_2(HML_t) + \kappa(ER_t) + \sum_{j=0}^{8}\delta_j^{(-)}(Oil_{t-j}^{(-)})$$
$$+ \sum_{j=0}^{8}\delta_j^{(+)}(Oil_{t-j}^{(+)}) + \sum_{j=0}^{8}\varphi_j^{(-)}(Gasoline_{t-j}^{(-)}) + \sum_{j=0}^{8}\varphi_j^{(+)}(Gasoline_{t-j}^{(+)}) + \varepsilon_t \tag{1}$$

Where $\varepsilon_t$ is an error term used to idiosyncratic behaviours not explainable by the other terms in the model, that as discussed below will be assumed to follow a generalized auto-regressive conditionally heteroskedastic process, which is known to be a common feature of financial time series.

This dynamic model specification allows for long and short run effects of gasoline and oil to be obtained using the information contained in the lag terms. Taking a response to an oil price rise as an example, the short run effect is simply given by the contemporaneous change in stock returns given a unit rise in the price of oil:

$$\frac{\partial R_{it}}{\partial Oil_t^{(+)}} = \delta_0^{(+)} \tag{2}$$

Where $\delta_0^{(+)}$ is the coefficient on $Oil_t^{(+)}$ from Eqn. (1). The long run effect also takes into consideration the lagged effects as well as the current period effect, resulting in a long run effect of the form:

$$\frac{\partial R_{it}^*}{\partial Oil^{(+)*}} = \sum_{j=0}^{8}\delta_j^{(+)} \tag{3}$$

With similar expressions applying for oil price falls, gasoline price rises and gasoline price falls by substituting the respective coefficients into equations (2) and (3). With the general empirical specification established we next discusses aspects of the econometric implementation.

### 4.2 Treatment of Heteroskedasticity, Short Samples, Missing Data and Structural Breaks

The data used in the analysis cover the members of the Shanghai Composite Stock Index as of January 2014. As with any market, new firms are born, and some of the members of the index have as a result 'existed' for a shorter time than others. Most members of the market also experience infrequent periods of short-lived non-trade, creating a certain degree of missingness that must be remedied in the data. These, as well as issues relating to heteroskedasticity and controlling for structural breaks are discussed here.

#### *4.2.1 Heteroskedasticity and GARCH*

The data used in the analysis are weekly frequency, allowing fairly short-term relationships to be identified without increasing the required model complexity to handle intra-week trading patterns. Weekly financial data will however often contain sufficient volatility to justify allowing for a generalized auto-regressive conditionally heteroskedastic (GARCH) specification for the error process. Doing so helps to ensure that inference/statistical significance testing remains valid even in the presence of time-conditional heteroskedasticity. The standard GARCH(1,1) variance is used to control for such volatility's:

$$\varepsilon_t \sim N(0, h_t\sigma^2) \tag{4a}$$

$$h_t = \alpha_0 + \alpha_1 h_{t-1} + \alpha_2\varepsilon_{t-1}^2 \tag{4b}$$

In this equation the conditional variance $h_t$ is influenced by it's own past value as well as the previous periods value of the model residual, $\varepsilon_{t-1}$. Estimation is done using maximum likelihood given the recursive nature of GARCH processes.

*4.2.2 Short time series*

As discussed, not each of the firms have an equal number of observations owing to new firms being listed, either large domestic firms or multinationals that are launching a regional index on the Shanghai stock market. The type of GARCH model discussed above will in many cases not be able to be estimated using mainstream statistics packages when there are less than 100 observations.[5] For these instances, rather than simply estimating no model, instead a relatively simpler robust regression is done (by iterative re-weighted least squares) to provide coefficient estimates and inference that, at least attempts, to control for any heteroskedasticity that may be present in the data.

*4.2.3 Missing observations*

Occasional periods (several days etc.) of non-trade are a practical reality in financial markets. There are two ways in which these are often handled. The first is simply to remove the periods of non-trade, using only the remaining periods where trade occurred. In static market models this can be a simple solution. However the model here includes a dynamic component in the energy price shocks, and therefore simply removing some periods may have undesirable impacts on the time-series properties of the data and analysis and is less desirable than the following approach. Instead here the other common approach of carrying the last observation forward is applied. The logic behind the second approach is simple and valid: there is no trade, hence the price did not change, and must be the same as the previous period.

In addition to the infrequent periods of non-trade that are relatively easily handled, there is a particular group of firms who have a sizable number of consecutive missing observations. These are periods of systematic non-trade stretching over a number of weeks which may result from a number of reasons.

The most notable of these is the 'Special Treatment' (ST) status applied to firms with consistent poor financial performance. These firms are effectively forced by the market regulators to stop-trading for a period up to 12 months to offer a chance to stabilize their performance and avoid future losses on the value of the firm. However, in addition to the ST firms there appears to be a large amount of self-regulation where firms cease trading for periods ranging between 1–3 months or more. These do not fall under the special treatment status, but are nonetheless periods of systematic non-trade.

*4.2.4 Structural breaks*

The period of analysis covers amongst other things the 2008 Global financial crisis as well as other events that may trigger a structural shift in the financial outcomes of a company. These

5. We thank an anonymous referee for raising concern regarding the use of GARCH with as few as 100 observations. It is widely acknowledged that GARCH is most useful in long time series. In a robustness check, not reported in the paper, we re-estimated all models without assuming GARCH, using a robust linear model instead. The qualitative results are robust to the inclusion or exclusion of GARCH, although some quantitative differences occur.

might be economy-wide, industry specific or even firm specific events, and since each firm will react differently to any crisis, it is perfectly plausible that the existence, timing and extent of any shock should be firm specific.

A solution therefore is needed to account for possible structural instability within the modelling framework, ideally one which capable of locating one or more structural breaks whose dates are unknown to the analyst. For this purpose the non-parametric change point method (CPM) of Ross (2012) is used. This test provides a fast (which is particularly desirable given it will be applied nearly 1,000 times) and accurate way of identifying breaks in a time-series, where the breaks can be in either the mean or the variance of the series. The mechanics of the test are somewhat convoluted and cannot be discussed here, the interested reader should refer to Ross (2012) and associated references. In simple terms the test identifies exactly (i) if and when each statistical break in the time-series occurs (if any) and (ii) when they became detectable. In the present study only the information on the actual break date will be used.

The CPM test is applied to the standardized residuals from the model in equation (3), corrected for the modelled GARCH effects. If the standardized residuals experience a sudden change (structural break) in either their mean or variance then a single model is inappropriate for the full data. Such a change in mean or variance is sufficient evidence the coefficients in equation (3) may differ in parts of the sample, and justifies re-estimating models for each identified sub-sample. Separate GARCH models are then run for each of the identified sub-samples but only for breaks that are more than 100 observations apart, ensuring that GARCH can be applied to each of the sub-samples. This can be justified on the premise that two or more breaks within 100 consecutive observations might otherwise be regarded as a single protracted regime of market instability.

Estimation is done using the R (2013) software program and the packages RUGARCH, by Ghalanos (2013), and CPM, by Ross (2013) and MASS by Venables and Ripley (2002).

## 5. RESULTS

This section summarizes the results of 963 separate GARCH models, which each allow for (possibly multiple) unknown structural breaks, contain rich information on reactions to financial markets characteristics and exchange rate effects, as well as oil prices and gasoline prices. The reactions to energy prices differ between the short-run and the long-run and also reactions to price rises and price falls are not constrained to be the same. We note that while the estimations are resolved at the firm level, for pragmatic reasons the results are generally discussed at the industry level, but stress that industry insights based upon firm level estimates allow new and detailed insights regarding the within-industry effects to be revealed and highlighted. To this end, this section focuses on several key questions of interest:

- What are the distributions of reaction oil and gasoline price shocks?
- Which are the industries that are most heavily affected by oil price shocks?
- Which are the industries that are most heavily affected by gasoline price shocks?
- Are the firms that are most heavily affected by oil shocks the same as those that are most heavily affected by gasoline shocks?
- What is the relationship between reactions to energy price shocks and the energy intensity of industries?
- Are ST firms—who are evidentially more prone to risk—also impacted more heavily by energy price shocks or not?

The above are by no means exhaustive of the range of questions that the data and methodology can answer, but are among the more important. As discussed earlier, the analysis separates the 963 firms into those which enter into ST (234 firms), and those that do not (the remaining 729 firms). Results for the ST firms are reported in a separate subsection towards the end of the results section.

For brevity we omit discussion of the market factors, and exchange rate effects. These are available upon request. Also we provide only a very brief discussion of structural breaks, again in the interests of brevity.

### 5.1 The Distributions of Reaction to Oil and Gasoline Shocks

We first look into the overall distributions of reaction to oil and gasoline price shocks. The principle aim at this point being to illustrate the widespread nature of both oil and gasoline shocks, and at the same time reveal sufficient uniqueness between them to justify the following more detailed introspections at the level of specific industries.[6] Among the 729 firms, 25.45% are affected by oil in the short-run e.g. some effect occurred within the same week, while 39.5% are affected by gasoline in the short-run. Thus a preliminary conclusion would be that reactions to gasoline price shocks are more pervasive than for oil shocks. When lag effects are accounted for, i.e. the long run effect, it is seen that 89.2% of firms financial values are affected by oil price shocks, and 95.7% affected by gasoline. There are several points here: the number of firms affected in the long-run is staggeringly greater than the number affected in the short-run; the gap between the numbers of firms affected is much smaller in the long-run (7.3%) than the short-run (54.2%); but perhaps most striking is that almost all firms react to both oil and gasoline price shocks. The conclusion for the short-run that more firms react to gasoline is upheld in the long-run.

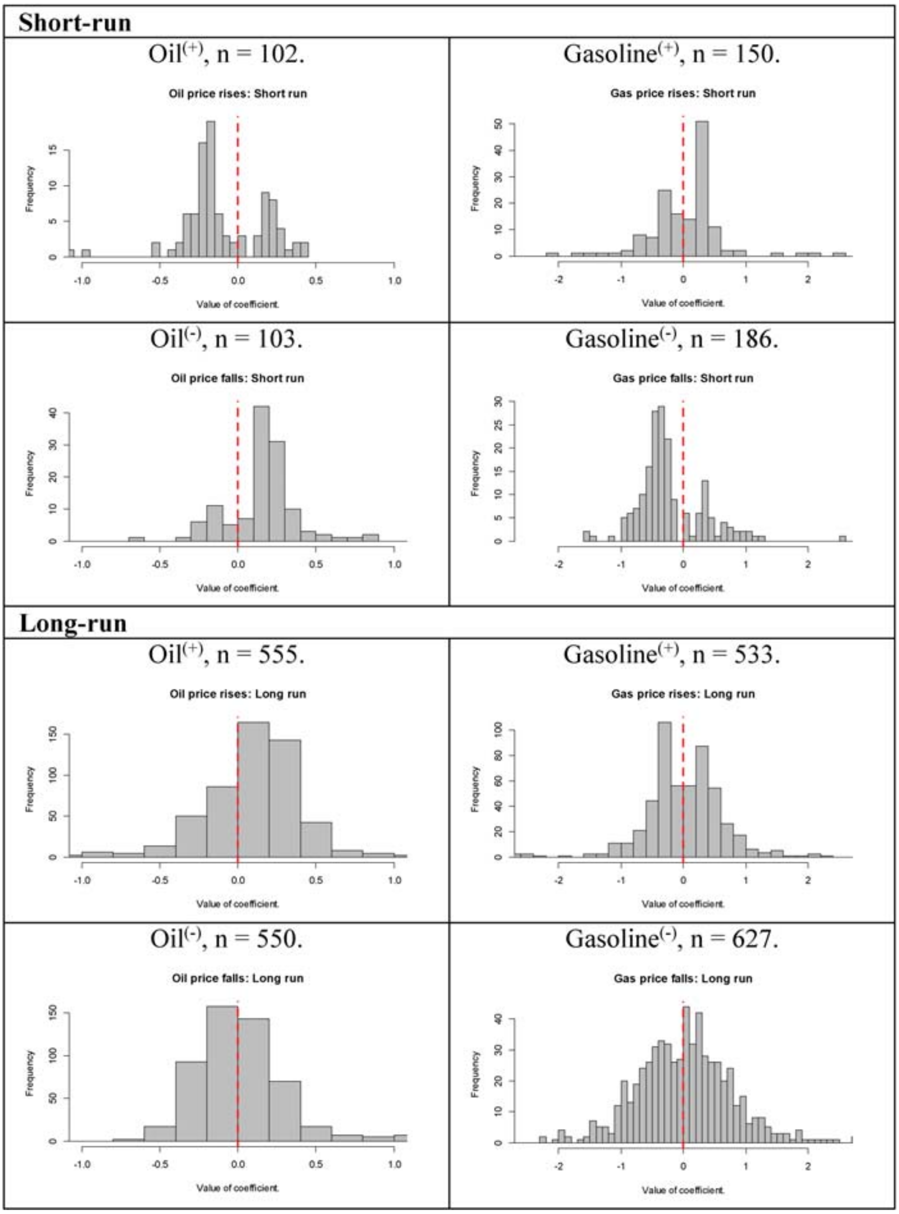
Figure 2 allows for some understanding of the size of effect imbued by energy prices shocks. This figure contains eight histograms, one for each of the short-run and long-run effects of oil and gasoline with respect to a price rise or a price fall. The estimated coefficients clearly illustrate a substantial degree of heterogeneity in how stocks react to energy price shocks. Consider for example the top-left plot which shows the distribution of (significant) coefficients on a current period oil price rise.[7] Of the 102 firms that react to an oil price rise in the short-run, the majority of coefficients are indeed negative, with a prominent cluster around $-0.2$. However there is a second clear, albeit smaller, cluster centered around $+0.2$ clearly suggesting that both positive and negative reactions occur. This is in all reality an entirely plausible result which, scanning across the remaining eight histograms, clearly is upheld for each of the energy price shocks considered.

Another noteworthy feature arising from Figure 2 relates to the observed asymmetries. For oil shocks in the short-run, roughly equal numbers of firms react to price rises and price falls, but for gasoline price shocks roughly 25% more firms respond to a price fall than do a price rise. Remaining focused on the short-run effects, the coefficients for oil and gasoline are in effect mirrors of each other. When oil prices rise, firm returns are deflated, but when gasoline prices rise the highest peak in the distribution clearly implies a positive reaction, though admittedly the density

6. It is worth noting that while we use the firm as the unit of analysis, we use higher level aggregates such as the industry for two reasons. First is that the number of firms makes reporting each unique firm a physical impossibility. Second is that aggregating across individuals helps firms retain a degree of anonymity. Focusing on GICS industrial classifications has the added advantage of providing a natural point of interpretation for the discussion.

7. This figure, and subsequent figures and tables reporting coefficient *values* are based on significant coefficients only. For firms where an energy price shock was found insignificant, the coefficients were excluded from the reported averages.

**Figure 2: Reactions to Energy Price Shocks**




*Note:* These plots show the distribution of firm level reactions to both oil and gasoline price shocks short-run and the long-run.

of the distribution in the negative region is obviously quite large. Conversely, when oil prices fall—and keeping in mind that falling prices are by definition negative, hence if the coefficient is also negative their multiplication will result in a positive number—then returns will decrease, and for gasoline price falls the returns will be increasing.

Yet another interesting feature derives from the comparison of the short-run to the long-run. In brief, confidence in the sign of any effect is greatly decreased, and the chance of a reaction to energy price-shocks being either positive or negative becomes almost the same.[8] For oil price shocks the skewness of the distributions can be visually discerned still, but is evidently much weaker than compared with the short-run. For gasoline price shocks the same cannot be said, with the long-run coefficients, notwithstanding some outlying spikes, looking somewhat reminiscent of a random normal distribution, with strong symmetry and a prominent peak close to zero. It is important to recall at this point that this figure plots *only* results that are significantly different from zero, hence that the peaks in the long-run go close to zero, but in the short-run do not, might imply a short-run over-reaction which is somehow `corrected for' in the long-run. A final feature of note is that the long-run coefficients for gasoline price changes take on a much larger range of values than for oil shocks, offering additional support to the notion that gasoline price changes may be more important than oil.

### 5.2 Industry Specific Reactions to Oil Price Shocks

With it having been established that reactions to energy price shocks among China's largest listed firms are pervasive to say the least and also that gasoline and oil price shocks create unique reactions, it becomes reasonable to ask which firms/industries are more affected than others, and how? Huang et al. (1996) and Gogineni (2010) among others, argue that some differences in reaction to oil shocks are perfectly intuitive: firms have different production process, with varying degrees of energy consumption needs, and also differing management structures that offer firm-specific possibilities to process, react to and maybe even benefit from a price shock. Since firms in different industries have unique characteristics, it stands to reason that they may also attract different investors, who may well also react differently to energy price shocks.

Table 2 summarizes a number of attributes of the results when grouping firms based on their global industrial classification system (GICS) sub-industry. Only industries with 10 or more firms, with the exception of 'Airlines' and 'Automobiles', which are of particular interest when considering oil or gasoline price shocks, are reported, the remaining (120) firms being grouped into an 'other' category. The table shows the number of firms in the industry, the share of firms affected by oil price shocks in the short-run, and the long run, and also the average size of the coefficient in the short-run and the long-run. Detail is provided for both price rises and price falls. A similar table is produced for gasoline shocks (Table 3), discussed further below.

From Table 2, in the short run the industries with the highest share of firms affected include 'Hotels Restaurants & Leisure' (54.55%), 'Beverages' (45.45%) and 'Communications equipment' (40%). In the long run there are several industries in which 100% of firms are affected: 'Multiline Retail'; 'Construction materials'; 'Paper & forest products'; 'Distributors'; 'Automobiles'; and 'Airlines'.

The sector with the largest number of firms is 'Machinery' (54 firms), followed closely by 'Metals and mining' (50 firms). For the 'Machinery' group of firms, in the short run only 33.33% are impacted by any change in the price of oil, either positive or negative. More of these firms react to a price fall (31.48%) than react to a price rise (18.52%), highlighting that in this industry greater attention needs to be given to price falls in the short run. This compares differently against the 'Metals and mining' sector for example where 20% of firms are affected by any shock, though

8. It might be interesting in future work to consider the nature of this result more closely, particularly the idea that a long-run reaction to an energy price shock may in effect be a lottery outcome. This might have useful implications in its own right.

**Table 2: Oil Price Shocks by GICS Industrial Classification—The Percentage of Firms Affected, and Average Size of Effect in Response to Price Rises and Price Falls in the Short Run and in the Long Run**

| Sector | # of firms | Short run | | | | | | Long run | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | % of firms affected | | | Average effect size | | | % of firms affected | | | Average effect size | | |
| | *Type of price shock:* | Any | Fall | Rise | Any | Fall | Rise | Any | Fall | Rise | Any | Fall | Rise |
| Machinery | 54 | 33.33 | 31.48 | 18.52 | 0.03 | 0.27 | −0.39 | 92.59 | 72.22 | 81.48 | 0.06 | 0.35 | −0.20 |
| Metals & Mining | 50 | 20.00 | 20.00 | 6.00 | 0.22 | 0.63 | −1.13 | 98.00 | 76.00 | 78.00 | 0.10 | 0.92 | −0.70 |
| Chemicals | 48 | 20.83 | 16.67 | 6.25 | 0.22 | 0.43 | −0.33 | 93.75 | 81.25 | 81.25 | 0.18 | 0.43 | −0.08 |
| Real Estate Management & Developers | 41 | 9.76 | 4.88 | 7.32 | −0.14 | −0.02 | −0.22 | 85.37 | 60.98 | 63.41 | 0.04 | −0.02 | 0.10 |
| Pharmaceuticals | 35 | 25.71 | 14.29 | 17.14 | −0.07 | 0.02 | −0.14 | 82.86 | 71.43 | 68.57 | −0.04 | −0.10 | 0.02 |
| Electrical Equipment | 35 | 31.43 | 31.43 | 2.86 | 0.29 | 0.32 | −0.04 | 80.00 | 71.43 | 65.71 | 0.12 | 0.34 | −0.12 |
| Textiles, Apparel & Luxury Goods | 28 | 14.29 | 10.71 | 7.14 | 0.35 | 0.60 | −0.02 | 85.71 | 71.43 | 64.29 | 0.11 | 0.32 | −0.12 |
| Construction & Engineering | 28 | 28.57 | 25.00 | 17.86 | −0.26 | −0.27 | −0.23 | 92.86 | 67.86 | 85.71 | −0.08 | 0.07 | −0.20 |
| Transportation Infrastructure | 27 | 33.33 | 29.63 | 22.22 | 0.07 | 0.11 | 0.03 | 96.30 | 88.89 | 70.37 | 0.16 | 0.30 | −0.01 |
| Oil, Gas & Consumable Fuels | 25 | 12.00 | 8.00 | 8.00 | 0.03 | 0.00 | 0.05 | 92.00 | 84.00 | 72.00 | 0.08 | 0.10 | 0.05 |
| Food Products | 25 | 24.00 | 8.00 | 24.00 | −0.12 | 0.26 | −0.24 | 88.00 | 64.00 | 64.00 | −0.02 | −0.09 | 0.06 |
| Multiline Retail | 23 | 26.09 | 17.39 | 17.39 | −0.01 | 0.19 | −0.20 | 100.00 | 78.26 | 91.30 | 0.01 | −0.07 | 0.08 |
| Trading Companies & Distributors | 22 | 13.64 | 9.09 | 4.55 | 0.25 | 0.24 | 0.25 | 86.36 | 68.18 | 72.73 | 0.12 | 0.03 | 0.20 |
| Auto Components | 18 | 22.22 | 22.22 | 11.11 | 0.21 | 0.21 | 0.21 | 83.33 | 72.22 | 72.22 | 0.03 | −0.04 | 0.09 |
| Independent Power Producers & Suppliers | 17 | 23.53 | 11.76 | 11.76 | 0.00 | −0.02 | 0.02 | 88.24 | 70.59 | 82.35 | 0.04 | −0.02 | 0.09 |
| Construction Materials | 16 | 12.50 | 12.50 | 0.00 | −0.01 | −0.01 | 0.00 | 100.00 | 93.75 | 93.75 | −0.13 | −0.20 | −0.06 |
| Commercial Banks | 14 | 21.43 | 21.43 | 14.29 | 0.02 | 0.00 | 0.04 | 92.86 | 85.71 | 78.57 | 0.10 | 0.10 | 0.11 |
| Paper & Forest Products | 13 | 30.77 | 15.38 | 23.08 | −0.63 | −0.75 | −0.55 | 100.00 | 92.31 | 92.31 | −0.26 | −0.12 | −0.39 |
| Road & Rail | 12 | 25.00 | 16.67 | 8.33 | 0.06 | 0.21 | −0.25 | 91.67 | 66.67 | 91.67 | 0.10 | 0.07 | 0.11 |
| Electronic Equip., Instruments | 12 | 33.33 | 25.00 | 25.00 | 0.12 | 0.11 | 0.14 | 91.67 | 66.67 | 91.67 | 0.15 | 0.16 | 0.15 |
| Hotels Restaurants & Leisure | 11 | 54.55 | 45.45 | 18.18 | 0.21 | 0.20 | 0.25 | 90.91 | 90.91 | 72.73 | 0.14 | 0.23 | 0.04 |
| Distributors | 11 | 36.36 | 27.27 | 18.18 | 0.15 | 0.08 | 0.26 | 100.00 | 81.82 | 90.91 | 0.16 | 0.08 | 0.24 |
| Beverages | 11 | 45.45 | 27.27 | 36.36 | −0.07 | 0.16 | −0.24 | 81.82 | 72.73 | 72.73 | −0.04 | −0.10 | 0.01 |
| Electric Utilities | 10 | 10.00 | 0.00 | 10.00 | 0.21 | 0.00 | 0.21 | 60.00 | 60.00 | 30.00 | 0.05 | 0.08 | 0.00 |
| Communications Equipment | 10 | 40.00 | 10.00 | 40.00 | −0.12 | 0.33 | −0.24 | 80.00 | 70.00 | 80.00 | −0.04 | −0.15 | 0.06 |
| * Automobiles | 9 | 44.44 | 44.44 | 11.11 | −0.31 | −0.29 | −0.39 | 100.00 | 88.89 | 77.78 | 0.14 | 0.69 | −0.48 |
| * Airlines | 4 | 25.00 | 25.00 | 25.00 | −0.21 | −0.20 | −0.21 | 100.00 | 100.00 | 75.00 | 0.11 | −0.02 | 0.19 |
| All Others | 120 | 24.46 | 16.41 | 14.30 | 0.04 | 0.07 | −0.05 | 88.41 | 74.64 | 72.86 | 0.05 | 0.21 | −0.08 |
| Total | 729 | 25.45 | 17.93 | 14.74 | 0.03 | 0.09 | −0.09 | 89.23 | 75.55 | 74.47 | 0.05 | 0.17 | −0.07 |

*Notes:* * Denotes a sector with less than 10 firms, but likely to be of particular interest when considering oil/gasoline price shocks. 'All other' firms are the sum of all sectors, except those of special interest, with fewer than 10 firms. Short run and Long run effects are as described in equations (2) and (3) of the main text. For the purpose of calculating the numbers reported in this table, all insignificant coefficients are set equal to zero.

price falls remain more relevant with all of the 20% of firms in this industry reacting to a price fall, and only 6% reacting to a price rise. On average for the sample of firms in the table, 25.45% of firms have a short-run reaction to oil price changes. The picture is very different in the long run, where on average 89.23% of firms react to an oil price change. This clearly demonstrates the importance of modelling dynamic effects of oil pricing. Across the sectors in Table (2), on average 63.78% more firms have a long run reaction to oil price changes than have a short run reaction.

Regarding the observed asymmetries, as per Figure 2, the asymmetry patterns revealed in Table 2 are generally much stronger in the short-run than in the long-run. For the short run the average percentage of firms reacting to a price fall is 17.93% which is 22% more than the percentage of firms reacting to a price rise, which is 14.74%. For the long run 75.55% of firms react to a price fall, and 74.47% to a price rise, the difference between these two numbers being only 1.5%, clearly much closer than in the short run.

The average effect signs are largely as expected, a rise in the price of oil, either in the short-run or the long-run will be expected to have a negative impact on returns. Conversely a fall in the price of oil will in general result in a positive impact on returns. This is broadly consistent with the conclusions offered in many previous studies. The range of effects across the industries is however also clear, with many instances of both positive and negative values. The implication of this is that any study aggregating firms, either into industry portfolios or other aggregations such as national level, may unintentionally be confounding effects: if the chosen aggregation inadvertently puts firms that react positively to a price rise with firms that react negatively, there will arise a 'cancelling-out' effect that might result in a conclusion of statistical insignificance. Put another way, the strong evidence of heterogeneity offers support that analysis from the firm level may be the best way to truly understand the relationship between shocks and stocks.

### 5.3 Industry Specific Reactions to Gasoline Price Shocks

Turning attention towards gasoline shocks, reported in Table 3, to enable the most direct comparison, this part begins by looking at the 'Machinery' and 'Metals and mining' sectors. For 'Machinery', in the short run 33.33% of firms are affected by a gasoline price shock, which is the same number as were impacted by any change in the price of oil, refer back to Table (2). Fewer of these firms react to a price rise (18.52%) than react to a price fall (25.93%). For the 'Metals and mining' sector 42% of firms are affected by any gasoline shock in the short-run, which is much larger than the 20% of firms affected by an oil shock. Fewer firms react to price falls (24%) than to a price rise (32%). On average for the sample of firms in the table, 39.48% of firms in any given industry will have a short-run reaction to gasoline price changes, which is 14.03% more than react to oil price shocks. As was the case with oil shocks, for gasoline shocks the number of firms affected in the long-run (95.67%) is much greater than compared with the short-run (39.48%).

For gasoline shocks the average size of the coefficients show some arguably more interesting patterns than for oil shocks. In the short-run the average coefficient value across all industries in reaction to a gasoline price fall is $-0.21$. Similarly, when gasoline prices are rising, the average returns are increasing, albeit with an average coefficient very close to zero (0.03). In the long-run the relationships are much closer in nature to those seen for oil inasmuch as the long-run reaction to falling prices is an increase in returns (0.07), while rising gasoline prices cause returns to decrease ($-0.22$). The size of these coefficients is quite different compared to those for oil shocks, where for oil shocks in the long-run the price fall was clearly what impacted firms returns the greatest, but for gasoline it is the price rise which results in the bigger impact.

**Table 3: Gasoline Price Shocks by GICS Industrial Classification—The Percentage of Firms Affected, and Average Size of Effect in Response to Price Rises and Price Falls in the Short Run and in the Long Run**

| Sector | # of firms | Short run | | | | | | Long run | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | % of firms affected | | | Average effect size | | | % of firms affected | | | Average effect size | | |
| | *Type of price shock:* | Any | Fall | Rise | Any | Fall | Rise | Any | Fall | Rise | Any | Fall | Rise |
| Machinery | 54 | 33.33 | 25.93 | 18.52 | 0.12 | 0.18 | 0.04 | 98.15 | 87.04 | 72.22 | −0.04 | 0.06 | −0.15 |
| Metals & Mining | 50 | 42.00 | 24.00 | 32.00 | 0.30 | 0.64 | 0.05 | 90.00 | 80.00 | 76.00 | −0.35 | −0.06 | −0.65 |
| Chemicals | 48 | 37.50 | 20.83 | 22.92 | −0.18 | −0.26 | −0.10 | 95.83 | 85.42 | 75.00 | −0.20 | 0.04 | −0.47 |
| Real Estate Management & Developers | 41 | 21.95 | 12.20 | 9.76 | −0.43 | −0.58 | −0.24 | 92.68 | 78.05 | 65.85 | −0.02 | −0.02 | −0.02 |
| Pharmaceuticals | 35 | 40.00 | 28.57 | 14.29 | −0.17 | −0.32 | 0.15 | 97.14 | 91.43 | 80.00 | −0.16 | −0.36 | 0.08 |
| Electrical Equipment | 35 | 42.86 | 20.00 | 25.71 | 0.10 | −0.25 | 0.37 | 97.14 | 85.71 | 74.29 | 0.19 | 0.22 | 0.15 |
| Textiles, Apparel & Luxury Goods | 28 | 25.00 | 21.43 | 7.14 | −0.08 | −0.25 | 0.41 | 100.00 | 92.86 | 71.43 | −0.13 | 0.14 | −0.49 |
| Construction & Engineering | 28 | 35.71 | 28.57 | 21.43 | −0.34 | −0.35 | −0.34 | 96.43 | 89.29 | 71.43 | −0.17 | −0.11 | −0.24 |
| Transportation Infrastructure | 27 | 33.33 | 22.22 | 33.33 | −0.08 | −0.14 | −0.04 | 96.30 | 88.89 | 66.67 | 0.29 | 0.26 | 0.33 |
| Oil, Gas & Consumable Fuels | 25 | 40.00 | 32.00 | 16.00 | 0.41 | 0.60 | 0.02 | 92.00 | 84.00 | 76.00 | 0.30 | 0.66 | −0.10 |
| Food Products | 25 | 48.00 | 28.00 | 24.00 | −0.22 | −0.49 | 0.11 | 96.00 | 84.00 | 72.00 | −0.09 | −0.41 | 0.28 |
| Multiline Retail | 23 | 34.78 | 17.39 | 21.74 | 0.19 | 0.02 | 0.33 | 100.00 | 86.96 | 91.30 | 0.09 | −0.01 | 0.19 |
| Trading Companies & Distributors | 22 | 36.36 | 31.82 | 9.09 | −0.38 | −0.43 | −0.21 | 100.00 | 90.91 | 68.18 | −0.17 | −0.31 | 0.01 |
| Auto Components | 18 | 22.22 | 0.00 | 22.22 | 0.54 | 0.00 | 0.54 | 94.44 | 77.78 | 61.11 | −0.04 | 0.01 | −0.10 |
| Independent Power Producers & Suppliers | 17 | 41.18 | 41.18 | 5.88 | −0.43 | −0.39 | −0.74 | 100.00 | 100.00 | 52.94 | −0.30 | −0.26 | −0.37 |
| Construction Materials | 16 | 37.50 | 31.25 | 18.75 | −0.24 | −0.32 | −0.09 | 87.50 | 87.50 | 62.50 | 0.03 | 0.05 | 0.01 |
| Commercial Banks | 14 | 35.71 | 28.57 | 14.29 | 0.17 | 0.13 | 0.24 | 100.00 | 100.00 | 92.86 | −0.06 | 0.05 | −0.18 |
| Paper & Forest Products | 13 | 46.15 | 23.08 | 30.77 | −0.04 | −0.54 | 0.34 | 92.31 | 69.23 | 76.92 | −0.32 | −0.03 | −0.57 |
| Road & Rail | 12 | 50.00 | 33.33 | 25.00 | 0.17 | 0.29 | 0.01 | 91.67 | 83.33 | 58.33 | 0.24 | 0.35 | 0.08 |
| Electronic Equip., Instruments | 12 | 16.67 | 16.67 | 8.33 | −0.47 | −0.42 | −0.56 | 91.67 | 75.00 | 50.00 | −0.15 | −0.02 | −0.35 |
| Hotels Restaurants & Leisure | 11 | 36.36 | 27.27 | 27.27 | −0.14 | −0.27 | −0.01 | 90.91 | 81.82 | 81.82 | 0.01 | −0.03 | 0.05 |
| Distributors | 11 | 63.64 | 45.45 | 36.36 | −0.51 | −0.61 | −0.37 | 100.00 | 100.00 | 54.55 | −0.02 | 0.12 | −0.30 |
| Beverages | 11 | 54.55 | 36.36 | 27.27 | −0.09 | −0.30 | 0.19 | 100.00 | 100.00 | 90.91 | 0.01 | −0.03 | 0.06 |
| Electric Utilities | 10 | 30.00 | 10.00 | 20.00 | −0.13 | −0.48 | 0.04 | 90.00 | 90.00 | 60.00 | −0.16 | −0.26 | −0.01 |
| Communications Equipment | 10 | 20.00 | 20.00 | 0.00 | −0.14 | −0.14 | 0.00 | 90.00 | 70.00 | 80.00 | −0.05 | −0.12 | 0.02 |
| * Automobiles | 9 | 33.33 | 22.22 | 22.22 | 0.13 | 0.38 | −0.12 | 88.89 | 88.89 | 55.56 | 0.13 | 0.59 | −0.62 |
| * Airlines | 4 | 33.33 | 33.33 | 33.33 | −0.43 | −0.71 | −0.15 | 100.00 | 66.67 | 66.67 | −0.61 | −0.19 | −1.03 |
| All Others | 120 | 37.84 | 29.79 | 25.98 | −0.03 | −0.21 | 0.09 | 86.44 | 79.72 | 75.15 | −0.06 | 0.14 | −0.25 |
| Total | 729 | 39.48 | 29.40 | 23.97 | −0.07 | −0.21 | 0.03 | 95.67 | 87.26 | 77.53 | −0.07 | 0.07 | −0.22 |

*Notes:* * Denotes a sector with less than 10 firms, but likely to be of particular interest when considering oil/gasoline price shocks. 'All other' firms are the sum of all sectors, except those of special interest, with fewer than 10 firms. Short run and Long run effects are as described in equations (2) and (3) of the main text. For the purpose of calculating the numbers reported in this table, all insignificant coefficients are set equal to zero.

**Table 4: Rankings of the 'Most-Affected' Industries**

| | | Oil | | Gasoline | | |
|---|---|---|---|---|---|---|
| **GICS Industrial sector** | **# of firms** | Fall | Rise | Fall | Rise | **Avg. Rank** |
| Beverages | 11 | 1 | 22 | 5 | 7 | 8.75 |
| Communications Equipment | 10 | 2 | 2 | 10 | 2 | 4 |
| Electric Utilities | 10 | 3 | 18 | 11 | 18 | 12.5 |
| Machinery | 54 | 4 | 24 | 14 | 16 | 14.5 |
| Trading Companies & Distributors | 22 | 5 | 15 | 8 | 6 | 8.5 |
| Distributors | 11 | 6 | 8 | 19 | 3 | 9 |
| Hotels Restaurants & Leisure | 11 | 7 | 1 | 13 | 15 | 9 |
| Pharmaceuticals | 35 | 8 | 21 | 23 | 25 | 19.25 |
| Electronic Equip., Instruments | 12 | 9 | 13 | 9 | 20 | 12.75 |
| Auto Components | 18 | 10 | 4 | 25 | 17 | 14 |
| Oil, Gas & Consumable Fuels | 25 | 11 | 3 | 16 | 14 | 11 |
| Electrical Equipment | 35 | 12 | 10 | 21 | 21 | 16 |
| Chemicals | 48 | 13 | 9 | 4 | 24 | 12.5 |
| Real Estate Management & Developers | 41 | 14 | 5 | 20 | 4 | 10.75 |
| Metals & Mining | 50 | 15 | 23 | 12 | 13 | 15.75 |
| Paper & Forest Products | 13 | 16 | 6 | 15 | 22 | 14.75 |
| Multiline Retail | 23 | 17 | 14 | 2 | 1 | 8.5 |
| Independent Power Producers & Suppliers | 17 | 18 | 17 | 22 | 12 | 17.25 |
| Textiles, Apparel & Luxury Goods | 28 | 19 | 11 | 18 | 23 | 17.75 |
| Commercial Banks | 14 | 20 | 7 | 6 | 11 | 11 |
| Road & Rail | 12 | 21 | 20 | 24 | 9 | 18.5 |
| Construction & Engineering | 28 | 22 | 25 | 3 | 5 | 13.75 |
| Food Products | 25 | 23 | 12 | 1 | 10 | 11.5 |
| Transportation Infrastructure | 27 | 24 | 16 | 17 | 19 | 19 |
| Construction Materials | 16 | 25 | 19 | 7 | 8 | 14.75 |

*Note:* The ranks are based on the size of the average coefficients within each industry, in absolute terms. Refer back to Tables (2) and (3) for the size/sign of the average coefficients.

From Table 3 in the short run the industries with the highest share of firms affected include 'Distributors' (63.64%), 'Beverages' (54.55%) and 'Road and Rail' (50%). In the long run there are several industries in which 100% of firms are affected: 'Textiles, Apparel & Luxury Goods'; 'Multiline Retail'; 'Trading Companies & Distributors'; 'Independent Power Producers & suppliers'; 'Commercial Banks'; 'Distributors'; 'Beverages' and 'Airlines'.

### 5.4 Are the Firms Affected Most Heavily by Oil Shocks and Gasoline Shocks the Same?

The discussion to this point has offered commentary as to how and where oil shocks matter, demonstrating that both types of shocks are important, and that they have differing effects in the long-run, the short-run and seemingly across industries. Here more direct attention is given to the question of whether the industries that are most heavily affected by oil shocks are the same as those most heavily affected by gasoline price shocks.

Table 4 offers rankings of the most-affected industries based on the long-run reaction to energy price shocks. The rank of a firm is based on the absolute value of the average coefficient within the industry, and is therefore intended to reflect which industries are most heavily affected, without being concerned about the sign of reaction.[9] The industry most heavily affected by oil price

9. Considering the sign of the effect may be interesting in some regards also, but here the purpose is simply to highlight that the rankings are clearly different. For readers interested in ranking sign effects, the information in Tables (2) and (3) can be referred back to.

falls, ranking number 1, is ‘Beverages’. Their rank with respect to price rises is however 22, making the industry one of the least affected by price rises, thus reactions to oil price shocks of different types are not alike. For gasoline price shocks the ‘Beverages’ sector ranks 5th for price falls and 7th for price rises. The industry most heavily affected by gasoline price falls is ‘Food products’, ranking number 1 in response to price falls, but number 10 in response to price rises. Interestingly this sector ranks number 23 under oil price falls, clearly indicating that rankings for gasoline and oil can dramatically differ. Scanning the columns of Table 4, no strong patterns emerge. Some industries like ‘Communications equipment’ rank highly in response to most price changes, similarly ‘Pharmaceuticals’ ranks low in most. However other sectors such as ‘Auto components’ or ‘Paper and forest products’ have much more sporadic patterns. Industries clearly highlighting that firms heavily affected by shocks from gasoline but not from oil include ‘Construction and engineering’ and ‘Multiline retail’. Sectors heavily impacted by oil and not by gasoline are less obvious. Sectors heavily affected by oil price falls, are often quite unaffected by oil price rises and vice versa.

Figure 3 offers an alternative lens on whether oil and gasoline price shocks imbue the same effects, by plotting the empirical contributions of oil and gas for selected industries. These empirical effects are obtained by first adding together the oil and gasoline price variables (both positive and negative), and their lags, multiplied against their respective coefficients for each individual firm. These fitted components are then added up across all members of the portfolio i.e. for industry $k$ the empirical oil and gasoline effects are defined as:

$$\text{Oil effect}_{\text{k}} := \sum_k \left[ \sum_{j=0}^{8} \hat{\delta}_{kj}^{(-)} (Oil_{t-j}^{(-)}) \; + \sum_{j=0}^{8} \hat{\delta}_{kj}^{(+)} (Oil_{t-j}^{(+)}) \right] \tag{5a}$$

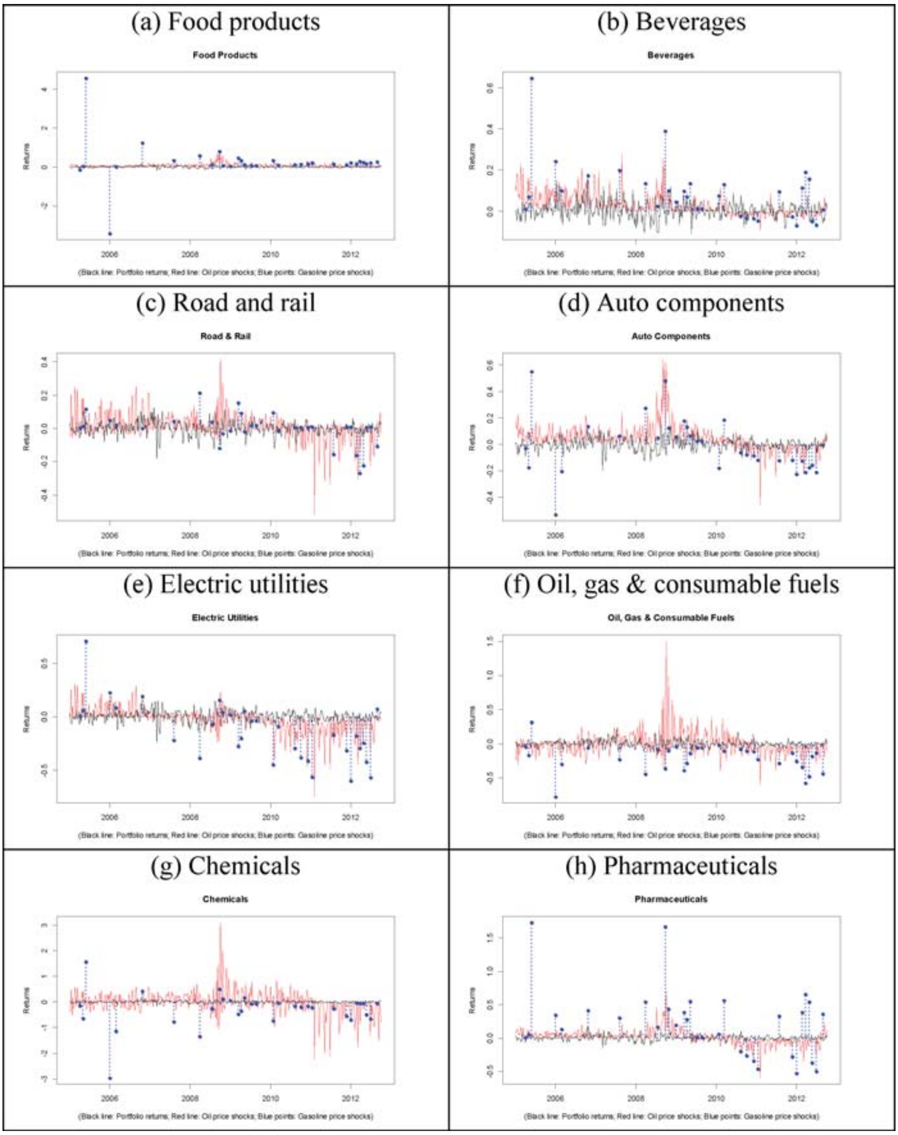
$$\text{Gasoline effect}_{\text{k}} := \sum_k \left[ \sum_{j=0}^{8} \hat{\varphi}_{kj}^{(-)} (Gasoline_{t-j}^{(-)}) \; + \sum_{j=0}^{8} \hat{\varphi}_{kj}^{(+)} (Gasoline_{t-j}^{(+)}) \right] \tag{5b}$$

Eight industries are chosen, attempting to show a balance of different business sectors that a-priori might be expected to be more or less affected by energy price shocks. For each plot in Figure 2 a red line shows the oil effect and the blue dots (with dashed drop-lines) the gasoline effect. The black lines show the actual returns on the industry portfolio. Given the price regulation of gasoline in China, the observed effects of gasoline will occur much less frequently than for oil.

Panels (a) and (b) of Figure 3 show the effects over time of gasoline and oil price shocks on the ‘Food producers’ and ‘Beverages’ sectors. The most obvious feature is the large impact that gasoline price shocks have on ‘Food producers’, being much more dominant than oil, and in general having positive net effects. For ‘Beverages’ one of the more interesting features is the marked decreased in effect of oil shocks after 2008/2009. Panels (c) and (d) show two transport related sectors, which as might be expected are affected strongly by both oil and gasoline price shocks. An interesting feature, more notable for the transport related firms than for the food related firms, is that the known oil price spike (and crash) of 2008 results in positive returns. A similar feature is seen in panel (f), the ‘Oil, gas & consumable fuels’ sector. For ‘Electric utilities’ in panel (e) this effect is not present, and the oil price movements in 2008 can be seen but are evidently more subtle. Lastly panels (g) and (h) show the ‘Chemicals’ and ‘Pharmaceuticals’ sectors, which are often heavy downstream users of oil related products.

The various panels in Figure 3 reveal that the true impact of oil and gasoline shocks differ quite widely from one industry to the other. While intuitive, these types of findings have largely evaded empirical literature, due perhaps to the substantial amount of computation required to obtain

**Figure 3: The Contribution of Oil Shocks (red line) and Gasoline Shocks (blue dots with dashed drop-lines) to the Returns of Selected Sub-industrial Manufacturing Portfolios (black lines)**




them. Clearly there are things here that need to be explored and understood further, perhaps through sector specific case studies.

### 5.5 Price Shocks and the Level of Energy Intensity

It has been argued in some previous studies that the energy intensity of an industry is a key factor that can be used to describe when energy price shocks are likely to be significant, for example Lee and Ni (2002) showed that price shocks are more likely to affect industries with a

**Table 5: Energy Intensity for China's Key Industrial Sectors Using Classifications from the Chinese National Bureau of Statistics (NBS) along with the Average Reactions to Energy Price Shocks for the Same Industries**

| | En. Int | $Oil^{(-)}$ | $Oil^{(+)}$ | $Gasoline^{(-)}$ | $Gasoline^{(+)}$ |
|---|---|---|---|---|---|
| Production and Supply of Water | 1.55 | 0.20 | −0.07 | −0.40 | 0.07 |
| Manufacture of Chemical Products | 1.05 | 0.52 | −0.18 | 0.32 | −0.41 |
| Mining and Processing of Non-metal Ores | 1.02 | −0.16 | −0.09 | 0.07 | −0.02 |
| Manufacture of Paper and Paper Products | 0.64 | 0.28 | 0.13 | 0.09 | 0.23 |
| Production and Supply of Electric and Heat Power | 0.59 | 0.42 | −0.33 | 0.48 | −0.76 |
| Processing of Petroleum, Coking, Processing of Nuclear Fuel | 0.52 | 0.74 | −0.29 | 1.11 | −1.56 |
| Mining and Washing of Coal | 0.49 | 0.20 | −0.17 | 0.62 | −0.19 |
| Processing of Wood Products | 0.48 | −0.58 | −2.06 | −0.04 | −2.02 |
| Manufacture of Artwork and Other Manufacturing | 0.43 | 0.03 | 0.01 | 0.03 | 0.01 |
| Manufacture of Metal Products | 0.37 | 0.70 | −0.58 | −0.21 | −0.48 |
| Production and Supply of Gas | 0.36 | 1.14 | −0.60 | −1.12 | −0.02 |
| Manufacture of Textile | 0.35 | −0.09 | 0.00 | 0.78 | −0.44 |
| Extraction of Petroleum and Natural Gas | 0.31 | 0.09 | 0.07 | −0.44 | −0.31 |
| Printing, Reproduction of Recording Media | 0.26 | 0.22 | 0.15 | 0.04 | 0.03 |
| Manufacture of Foods | 0.18 | 1.08 | −0.57 | 0.58 | −1.38 |
| Manufacture of Medicines | 0.17 | 0.06 | −0.04 | −0.30 | −0.19 |
| Manufacture of Beverages | 0.15 | 0.04 | 0.01 | −0.28 | −0.07 |
| Processing of Food from Agricultural Products | 0.14 | −0.06 | 0.11 | −0.20 | 0.13 |
| Manufacture of Special Purpose Machinery | 0.13 | 0.45 | −0.31 | −0.20 | −0.25 |
| Manufacture of Clothes | 0.10 | 0.00 | 0.28 | −0.15 | 0.21 |
| Manufacture of Furniture | 0.08 | 2.15 | −0.96 | 0.16 | −2.00 |
| Manufacture of Transport Equipment | 0.08 | 0.29 | −0.08 | 0.37 | −0.12 |
| Manufacture of Electrical Machinery and Equipment | 0.07 | 0.54 | −0.27 | 0.50 | −0.47 |
| Manufacture of Communication Equipment | 0.05 | −0.03 | −0.05 | −0.02 | −0.15 |
| *Average:* | 0.40 | 0.34 | −0.25 | 0.07 | −0.42 |

*Notes:* All data in this table are based on 2011 values. The last four columns show the average coefficients in reaction oil price falls, oil price rises, gasoline price falls and gasoline price rises.
En. Int. refers to energy intensity The sectors are ranked by their respective levels of energy intensity.

high demand for energy e.g. more energy intensive industries. As pointed out above, when we take the unit of analysis down to the firm level, the reaction to oil and gasoline price shocks occur in more than 90% of firms. As such questions implied by previous research, such as whether energy intensive industries are more susceptible to energy price shocks are effectively muted. In light of this, a more pertinent question becomes whether industries which have a level of higher energy intensity suffer demonstrably larger reactions to energy price shocks than those with lower energy intensity?

Table 5 reports the energy intensity of key Chinese industrial sectors, as well as average coefficient values for the energy price shock variables in the designated industry. The energy intensity of each industry is calculated using data from the Chinese National Bureau of Statistics (NBS), however the industrial classifications of the NBS do not align with GICS classifications for which the coefficients are estimated. We re-classify the GICS codes to match the NBS codes as best as we could. The data in Table 5 are for 2011, the latest year for which data are available on both industrial output and energy consumption from the NBS. The table is ordered by the industries with the highest energy intensity.

In brief, there is no clear association between energy intensity and the size of reaction to an energy price shock.[10] The conclusion we are led to, taking into consideration the discussions above, is that once the analysis of the relationship between energy price shocks and financial market behaviors is conducted at the level of the firm, then it turns out to be the case that almost every industry is affected. Thus we consider the previous assertions that energy intensity helps define *where* energy prices will impact financial markets to be a misnomer. Asking the deeper question of whether energy intensity and the scale of effect bare any relationship, we cannot find anything obvious. However, we must concede the limitations of our analysis on this matter, since the data on energy intensity are not firm specific, and the samples which determine the energy intensity and the coefficients on energy price shocks are likely to be very different. These questions must surely be investigated further using firm level data on energy consumption before any concrete conclusions could be drawn.

### 5.6 Special Treatment (ST) Firms

As discussed earlier, the Chinese financial markets contain a number of firms that have at some point in their trading history been allowed to enter into something called special treatment (ST). ST is a complicated feature of the Chinese financial markets that allows firms exhibiting sustained poor financial performance to enter into a prolonged period of non-trade—the idea being that during this ‘grace period’ the firm’s management will have an opportunity to rectify the managerial shortcomings that led to the poor-financial performance in the first place. After a grace period of up to 12 months the firm is allowed to start trading again. Due to the unique features that ST firms are exposed to, and the trading opportunities they may create for investors, analysts tend not to include them in study especially when creating and analyzing portfolios of firms.

Our analysis does not place firms into portfolios when estimating the reaction of asset prices to energy price shifts. As such, there is no ‘contamination’ from the ST firms onto the results of the non-ST firms reported above. However more interestingly this also allows for the ST firms themselves to be looked at separately to the non-ST firms, and ask the following question: Do ST firms, which as signaled by their entry into ST follow a different risk-profile to the wider market, suffer more extreme reactions to energy price shocks?

Table 6 presents summaries of the average coefficient value of ST and non-ST firms. The average coefficients on the oil and gasoline shocks in both the short-run and the long-run are reasonably similar. On the other hand the standard deviations for the ST firms are much tighter than for the non-ST firms. This is matched by a much smaller range of coefficients on the energy price shock terms. The reactions to oil shocks in the long-run are markedly different between the ST and non-ST firms. ST firms exhibit a positive reaction to a price rise, while non-ST firms have a much smaller (in absolute terms) negative reaction. With respect to an oil price fall, the financial returns of ST firms on average have a very small negative reaction, but the non-ST firms have a much more obvious positive reaction. Another difference is in how returns of these types of firms react to gasoline price rises, for ST firms there is a positive reaction, while for non-ST it is on average negative. Thus there would appear to be some quite important differences between ST and non-ST firms, a matter which future study might wish to explore further.

10. We also constructed a correlation matrix of the data in Table 5, but all correlations between energy price variables and energy intensity were as weak as they appear under a quick visual inspection.

**Table 6: Comparison of Coefficient Values Between Non-ST and ST Firms (ST = Special Treatment)**

| | Non-ST firms | | | | | ST firms | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | St. Dev. | Min. | Max. | % > 0 | Mean | St. Dev. | Min. | Max. | % > 0 |
| ***Market factors*** | | | | | | | | | | |
| Beta | 0.52 | 0.22 | −0.72 | 2.26 | 0.01 | 0.45 | 0.22 | −0.22 | 1.45 | 0.01 |
| HML | −0.14 | 0.43 | −5.81 | 2.37 | 0.28 | −0.09 | 0.47 | −3.38 | 2.14 | 0.20 |
| SMB | 0.42 | 0.39 | −1.01 | 3.33 | 0.04 | 0.63 | 0.49 | −1.07 | 3.67 | 0.02 |
| Ex. rate | −0.10 | 1.72 | −13.23 | 26.48 | 0.13 | 0.17 | 2.42 | −20.73 | 11.25 | 0.11 |
| ***Short run effects*** | | | | | | | | | | |
| Oil (+) | 0.00 | 0.17 | −2.23 | 2.24 | 0.10 | 0.03 | 0.22 | −0.89 | 1.55 | 0.09 |
| Oil (−) | 0.02 | 0.18 | −1.79 | 2.81 | 0.07 | −0.01 | 0.23 | −2.07 | 0.83 | 0.10 |
| Gas (+) | 0.00 | 0.25 | −4.10 | 3.27 | 0.10 | 0.00 | 0.23 | −1.27 | 1.33 | 0.12 |
| Gas (−) | −0.07 | 0.35 | −2.31 | 4.39 | 0.22 | −0.11 | 0.42 | −4.04 | 1.90 | 0.21 |
| ***Long run effects*** | | | | | | | | | | |
| Oil (+) | −0.06 | 1.16 | −19.60 | 5.66 | 0.27 | 0.21 | 0.52 | −3.45 | 3.87 | 0.19 |
| Oil (−) | 0.17 | 1.27 | −3.77 | 23.05 | 0.38 | −0.01 | 0.49 | −4.19 | 3.33 | 0.39 |
| Gas (+) | −0.15 | 1.31 | −16.62 | 5.28 | 0.39 | 0.08 | 0.94 | −5.74 | 5.88 | 0.36 |
| Gas (−) | −0.06 | 1.21 | −16.16 | 8.15 | 0.44 | −0.04 | 1.28 | −7.50 | 5.86 | 0.44 |

## 6. POLICY IMPLICATIONS

There are two areas of policy that this study can contribute to. The first is related to financial markets and behaviors. The study offers information of direct interest to investors, but also that may be used by regulators of financial markets. The second area is general economic policy, in particular the treatment of oil/gasoline price regulation throughout the Chinese economy.

### 6.1 Financial Policy

The analysis presented here touches on several areas of relevance to financial economics. The financial empirics of asset pricing models are the main foundation of the analysis. In this regard the analysis has clear implications for financial policy, in terms of providing information to investors that help better understand portfolio choices when faced by volatile international energy markets.

A simplistic interpretation of the results would be that they demonstrate that oil shocks matter to Chinese stocks, but this is actually already understood for example from Li et al. (2012) and Cong et al. (2008) among others. A more careful reading of the results is that they prescribe a hierarchy or menu of investment choices that can be used to rank firms by their relative resilience to international oil markets, allowing hedging and investment strategies to be more accurately implemented. The understanding of Gasoline prices is also a key contribution, since previous literature has offered virtually no discussion of this. Gasoline prices turn out to be more important to financial outcomes than oil prices do, at least in terms of the number of firms affected, but also generally in terms of the scale of effect too.

The results here do not support the assertions of Li et al. (2012) that China may be a good option for investors wishing to hedge against oil price hikes. The evidence presented here, based on the detailed bottom up perspective, demonstrates that risk from oil shocks is as prevalent in China as it would be expected to be anywhere else. Some industries stocks are negatively affected, while others are positively affected, and on balance in the long run, oil shocks have an almost equal chance of increasing returns as they do of driving them down.

### 6.2 Economic Policy

The results here contain information also of relevance to broader economic policy. The most obvious area of discussion is that of the domestic gasoline price regulation. The motivations for existing regulatory schemes are not well expounded by the National Development and Reform Commission, but it stands to reason that they were initially implemented to help shield domestic firms against shocks from international oil markets, allowing domestic producers to grow and mature, after which the extent of regulation can be lessened and in time removed. Over the years since the market reforms in China, the regulations on prices have clearly followed this trend, being particularly tight in the 1990's, and becoming increasingly closely tied to international prices (see for example Zhang et al. (2014) for further discussion).

If such 'shielding' principles were the reason for implementing regulation, it is not at all clear they are being successful. Gasoline price revisions clearly impact firm value, which is almost certainly due to changing costs of production. These impacts are as large and in many cases even larger than those due to oil price changes. However it must be conceded that the fact they change less frequently does generate a degree of firm stability which has its own advantages.

Given the nature of the study here, it is very difficult to say with any certainty that relaxing, or even removing, existing price regulation schemes could be advantageous, since the data make it difficult to set out counter-factual environments to test such hypotheses. But it is at the same time clear that they are not mitigating or diffusing the effects of price revisions. One possibility is that users of gasoline do not understand the regulation schemes well enough to be able to predict the timing and scale of future price revisions, in this regard early announcement and greater transparency on regulated price changes may be a cheap and easy to implement strategy. Perhaps though, and keeping in mind the deep oil dependency of China, it may be more useful to re-ask what the intended objectives of the regulation actually are, and whether they help really achieve these objectives.

The results regarding a lack of association between the energy intensity of an industry and the size of reactions of stock returns to energy price fluctuations may also have implications for policy. The level of energy intensity is an increasingly widely used target for policy makers, including within China, which has incorporated energy intensity targets into its most recent Five Year Plans. One view of the lack of correlation is that firms can potentially absorb energy price fluctuations without needing to adjust energy intensity. Or conversely that changes in energy consumption are not equally matched by changes in output across all firms/industries. However, as discussed, the available data on energy intensity has its limitations in the present study, and more detailed and deeper analysis is required to study this aspect of the results before being able to more carefully prescribe how policy might make use of/react to such a finding.

## 7. CONCLUSIONS

This paper sought out to (i) understand firm level reactions to international oil prices (ii) understand if firms also react to gasoline prices, which are more directly connected to most firms costs of doing business than oil prices are (iii) search for commonalities in industry level reactions to oil and gasoline price changes and (iv) try to reconcile the level of reaction against the energy structure of industries, using the energy intensity of an industry as a proxy. To recap, the main findings are as follows: (i) Around 90% of Chinese firms are affected by both oil and gasoline shocks in the long run; (ii) These effects differ with respect to price rises and price falls; (iii) These effects also differ widely between industrial sectors; and finally (iv) There is no clear relationship between the size of the risk exposure and the level of energy intensity, thus while energy structure may correlate with energy consumption, a further connection to energy price elasticity is self-evidently less straightforward.

The present study is one of very few to consider the reaction of individual firms to energy price shocks, most previous studies use higher level aggregates such as industries, or whole stock markets. The results of the analysis are rich. Oil shocks matter, but the reaction to oil shocks can be either positive or negative, the same is true also for gasoline. This is in some ways comforting—reinforcing what might be expected a-priori. The results further reveal that even within the same industry, the reaction to oil/gasoline price changes may be either positive or negative, and in this regard could have a cancelling out effect that at the aggregate level could imply statistical insignificance. The study here therefore offers a means by which many of the previous conflicting findings can be (at least partly) reconciled, since for want of a better term, ‘anything is possible’.

Current price regulation in China means that gasoline prices react slowly to oil shocks, being both delayed and diffused i.e. gasoline price shocks will be later, smaller and less frequent than oil price shocks. It nonetheless transpires that a greater number of firms react to gasoline price shocks than oil price shocks. Thus although regulated price changes are in principal foreseeable by market participants, they still impact the financial markets as if they were unexpected. Hence, the value of gasoline price regulation requires further consideration, at least as a protectionist policy, since it does not seem to shield against knee-jerk reactions by the financial markets.

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