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Policy shifts and stock market: Lessons from the US and China

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Abstract

Governments set legal framework and economic policies, which influence the economic-institutional environment in which financial actors operate. They levy taxes, provide subsidies and investments, enforce laws and punish law-breakers, regulate competition, etc. In recent years, many policy initiatives have been launched to stimulate the transition towards renewable energy (RE). The main question of this thesis is how the launching of such initiatives – and other major political events – have influenced stock prices of companies in two sectors (fossil fuel and renewable energy) and in two countries (the US and China). This study is of particular interest for the policymakers and investors in evaluating effectiveness of news about RE policy.

One challenge in measuring the impact of announcements on stock prices is that policy and legislative processes are slow and the news are gradual. Regulatory events usually involve multiple announcements, due to extensive negotiations and public debate. They are more likely to be anticipated compared with corporate announcements. Yet, there are many examples of policy announcement and political events having an impact on stock prices.

During the study I selected three important political events which could potentially shift RE policy and affect performance of energy firms: the 2012 presidential election in the US, the Paris agreement on climate change, and the 2016 presidential election in the US. The results of the study indicate that major political events affect the performance of energy firms.

In addition, the results indicate that news about RE policy positively affect the performance of RE firms, but they do not affect the performance of fossil fuel firms. This indicates that while RE policy encourage investments into RE firms, fossil firms do not perceive RE industry as a substantial competitor. Chinese RE firms are more affected by the news about policy announcements than US firms. This could be of two reasons: first, US political system is more open, thus, RE policy news could be more anticipated than Chinese; second, the US announcements might be less relevant than Chinese, due to heavy reliance of the US central government on state-level policies.

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1 Introduction

Growing concerns about climate change and environmental deterioration push governments across the world to change the energy system and develop systems that depend less on fossil fuels and rely more on renewable energy (RE) sources. Such transition towards the RE system requires large investments in RE (Johnson & Lubecker, 2009; Kaminker & Stewart, 2012). Financial resources of state governments are limited, thus, governments must encourage private investments in RE (Kaminker & Stewart, 2012). In encouraging private investments, policymakers use different policy instruments. Thereby, governments establish laws and regulations which affect decisions of financial market participants.

The information about future RE policy framework comes from both political events and direct announcements by the government about RE policies. One of the most influential political events is the presidential elections. Changes in government driven by the presidential elections lead to changes in political priorities regarding environment.

Government policy affect both firms' decision to invest in RE technologies (IRENA, 2016; OECD, 2012), and decision of market participants to invest in RE firms. First, RE policies affect the overall economic growth of countries, which in turn, affect demand for companies' products and companies' competitive position. Second, financial market is a signal receiver. Thus, favorable policy changes in the incentives and regulations towards renewables may send a signal to market participants to invest in RE firms.

How sensitive are stock prices of energy firms to such political events and policy signals? Studies show that events such as general elections (Kabiru et al. 2015), news regarding the peace process in the Middle East (Zach, 2003), international conflicts (Schneider & Troeger, 2006), climate change and environmental news (Beatty & Shimshack, 2010; Deak & Karali, 2014), and disasters (Capelle-Blancard & Laguna, 2010) influence stock market. Nevertheless, such an influence depends on the industry (Bouoiyour & Selmi, 2017), and event at hand (Kabiru et al., 2015).

One challenge in measuring the impact of regulatory events on stock prices is that policy and legislative processes are slow and the news are gradual. Regulatory events usually involve multiple announcements due to extensive negotiations and public debate, and are therefore more likely to be anticipated than corporate announcements (Binder, 1985a). Thus, it is uncertain when expectations of market participants has changed. It is, therefore, of

interest to investigate whether single announcements about RE policy affect firms' performance.

The starting point for my study is the Efficient Market Hypothesis (EMH) (Fama, 1970, 1991, 1995a), and event study methodology (Binder, 1998; Brown & Warner, 1985; MacKinlay, 1997; Schweitzer, 1989). Given the connection between performance of equity investors, the firm's success, its real asset (Bodie et al., 2011), and rationality of the marketplace, any significant new information will be reflected immediately in security prices (MacKinlay, 1997).

The thesis seeks to answer two questions: How do recent *political events* affect performance of RE and fossil firms? How do recent *RE policy announcement* affect the performance of RE and fossil firms?

I focus on the US and Chinese RE policies. The choice of the countries is justified by the fact that the US and China are the biggest polluters of greenhouse gases (Olivier et al., 2015). They have different political systems, which makes a comparative study interesting. In China, the central government¹ is the key policymaking body, therefore, market participants focus primarily on the state policies (Lo, 2014). On the other hand, the US federal government, in promoting development of RE, relies heavily on the policies of different states (Campbell, 2014). Such differences in political systems may result in different market responses to policy announcements.

The period of interest is 2012-2016 after the agreement in the UN climate negotiations referred to as the "Durban Platform for Enhanced Action" was reached (December 2011). This was a notable step forward as all countries, including the US and China, agreed on a future climate agreement of some "legally binding" nature. As a consequence of this agreement, the world expects that both countries will make efforts towards reducing CO₂ emission.

In addition, Chinese solar and wind power markets have been growing since 2004 (Zhang et al., 2013). In 2010, 10 photovoltaic (PV) manufactures, such as JinkoSolar, Yigli, and DAQO, were listed on the US stock exchange. Thus, the choice of the period is guided by the data availability and limitations.

¹ The NPC and its Standing Committee, and State Council exercise the state power to make laws. In 2010 China's government has established National Energy Commission. The Commission coordinates the overall energy policies. The purpose of the commission is to draft a new energy development strategy, evaluate energy security and coordinate international cooperation on climate change; carbon reduction and energy efficiency. https://en.wikipedia.org/wiki/National_Energy_Commission. Extracted: 20.03.2017.

I contribute to the literature by examining whether announcements made by China's and US government about RE policy affect stock prices of energy firms. My study is different from previous in several ways. First, to my knowledge there are no studies investigating the effect of news about RE policy for the most recent years. Second, I take a comparative approach and compare the effect of the US' and China's policies. Third, I analyze how policy announcements affect firms that operate within different RE technologies.

The results of the study are of interest to policymakers and investors. For policymakers the study is useful in evaluating effectiveness of announcements about RE policy and regulations. For investors, knowledge about the sensitivity of stock prices to political events and policy announcements will help to make more precise estimates of the profitability of future investments and decide on their stock portfolios.

The remainder of this thesis is structured as follows. Section 2 provides background to the study. Section 3 presents theory, and section 4 outlines and discusses data and methodology. Section 5 presents the empirical results, while section 6 gives a discussion of the results, in relation to theory and previous studies. Section 7 concludes.

2 Background

My motivation for studying political events and RE policy announcements, and their effect on the energy industry has been influenced by many factors: the dark projection of the future environmental situation (OECD, 2012), under-investments in RE (IRENA, 2016), question of possibility of market participants to anticipate government announcements about RE policy and its relevance. In this section I want to present a background to the main problems that I will discuss in this thesis.

2.1 The transition towards a low-carbon society

The production and consumption of energy increase in the world in general, and increase in both the US and China in particular. Economic and population growth are the leading drivers behind the increase of energy demand (BP, 2016b; IPCC, 2000; OECD, 2012; UN, 2015). Despite rapid increase in RE, fossil fuels will remain the major energy source for the next two decades (Figure 1), with share of 73.5% of total energy consumption in 2035.

Primary energy consumption is one of the main fundamental determinants of global greenhouse gas (GHG) emissions. High energy consumption leads to high emissions (IPCC, 2000). OECD (2012) projected that *without a more efficient policy* by 2050, the share of fossil-fuel based energy in the global energy mix will still remain at high level, GHG emissions will increase by 50%, and air pollution will become the world’s top environmental cause of premature death.

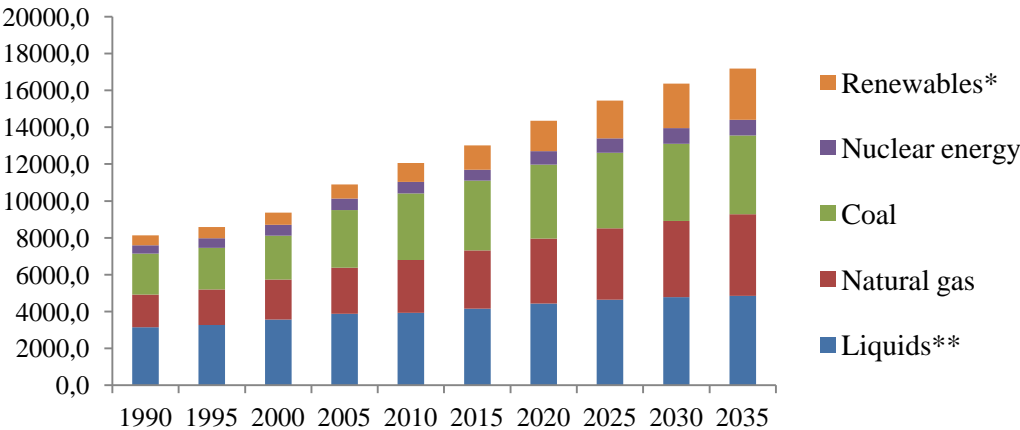


Figure 1: Total energy consumption by fuel, 1990-2035, million tones oil equivalent***

Source: (BP, 2016a)

***Energy consumption comprises commercially traded fuels, including modern RE used to generate electricity.

** Includes oil, gas-to-liquids and coal-to-liquids.

* Includes wind power, solar electricity, biofuels and other renewables.

In 2015, about 85% of all primary energy consumption in the world was derived from fossil fuels (see Figure 1). From which coal accounted for about 29% of the total energy consumption, natural gas - 24%, and liquids - 32%. The RE sources constituted just about 9% of total energy mix.

In China and the US oil, natural gas, coal, renewable energy, and nuclear power are primary sources of energy and the demand for energy increases in both countries (BP, 2016a). The growth in China’s energy demand between 2000 and 2015 was greater than the total energy demand of the European Union in 2015 (BP, 2016a). In 2015, 88.2% of total energy consumption was derived from fossil fuels. Coal represented the single largest category of energy consumption, with the share of 63.7%. When compared to the coal the share of the RE in the total energy mix is very small, with 1.4% share of wind power and only 0.3% of solar. The largest share of renewable generation is still hydropower, which constitutes just 8.5% of total energy consumption in China (see Figure 2).

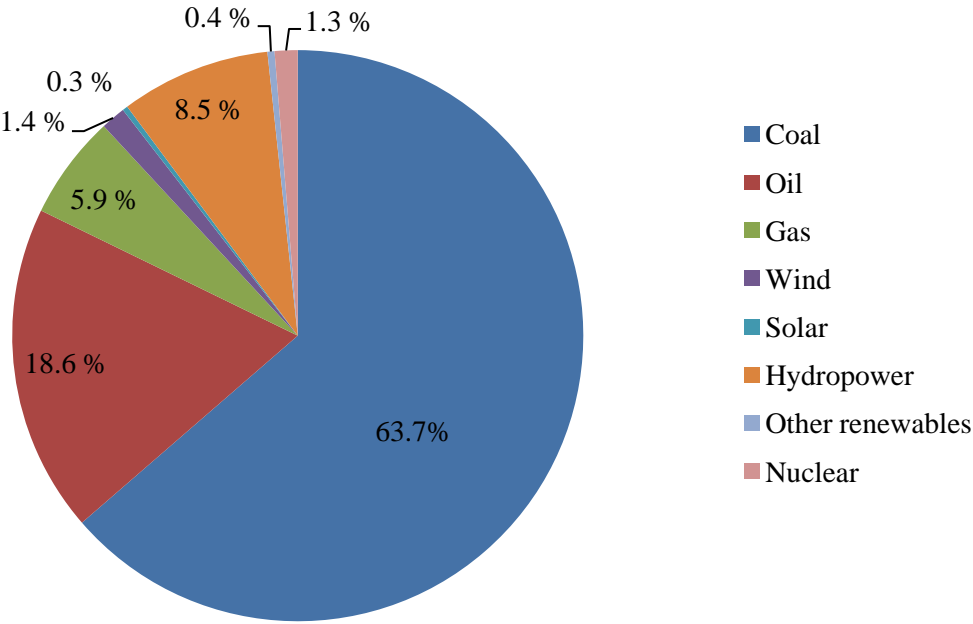
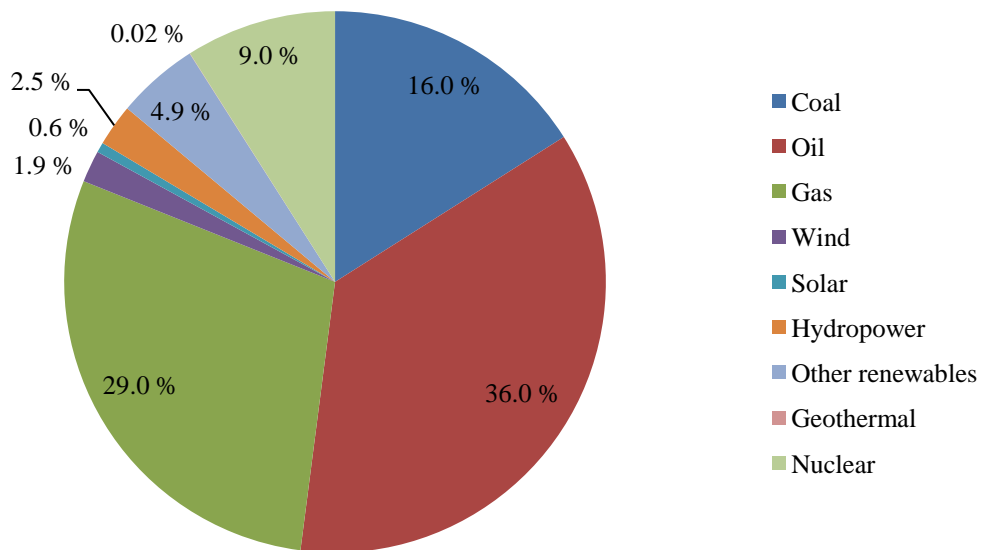


Figure 2: Primary energy consumption in China, 2015
Source: (BP, 2016a)

In the US, just like in China, fossil fuels remain the major primary energy source with its share of 81% in the total energy consumption in 2015. Oil represented the single largest category, with the share of 36%. The largest share of renewable generation was biomass, but it constituted just 4.9% of total energy consumption in the US.



Note: Sum of components may not equal 100% because of independent rounding

Figure 3: Primary energy consumption in the US, 2015

Source: (EIA, 2016)

Thus, fossil fuels are the major culprit of the GHG (Griffin, 2009; Olivier et al., 2015) and increase of the share of RE sources is one of options to decrease GHG emission (Foxon & Pearson, 2007; Jefferson, 2008). While, increase of RE share can be achieved through policies and regulations (Kaminker & Stewart, 2012; OECD, 2015), it is of interest to observe how the news of policies for promotion RE affect the performance of fossil fuel firms.

2.2 Energy investments

Since financial resources of state government are limited, government use policies in support of RE to induce investors to reallocate financial resources to the RE sector (IRENA, 2016; OECD, 2012). In 2015, fossil fuels remained the biggest recipient of supply-side investment, with 50% out of total energy investments. Oil and gas represented the largest single category of energy investments with 46% of total investments, while investments in RE was just 17% and remained below its potential (IEA, 2016; IRENA, 2016).

In 2015, China overtook the top position in energy investments from the US. This is done largely due to the record high level of electricity sector investments in China and the decline of the US oil and gas investment (IRENA, 2016).

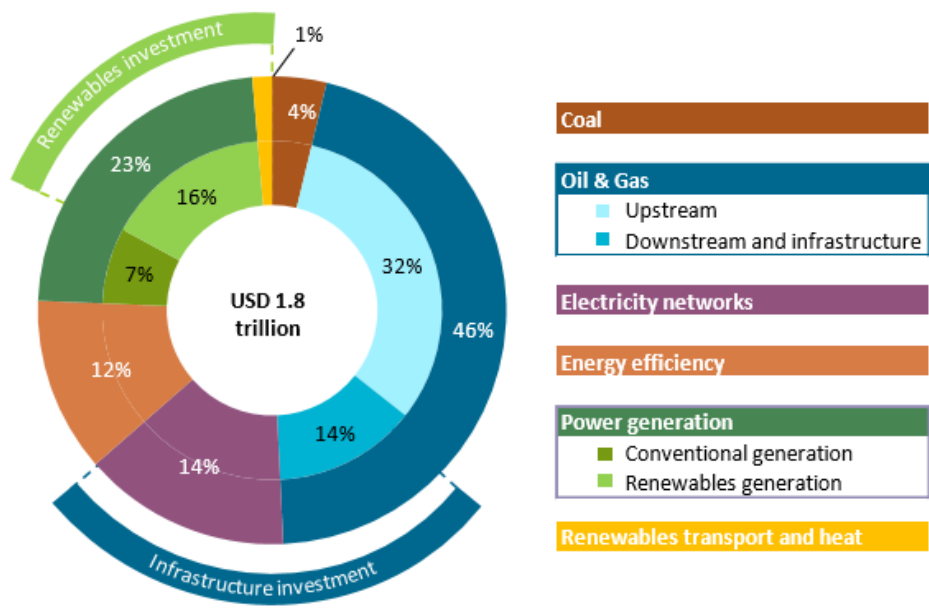


Figure 4: Global energy investments and its shares in 2015
 Source: International Energy Agency (IEA, 2016)

In 2015, global investments in RE, in spite of a substantial increase over the last 10 years, remained on 66% lower than in fossil fuel (see Figure 4). The amount of investments in RE was \$306 BN in 2015, while those in fossil fuels were \$900 BN. By sector solar and wind powers obtained the largest amount of RE investments with \$161 BN and \$110 BN respectively (BNEF, 2016).

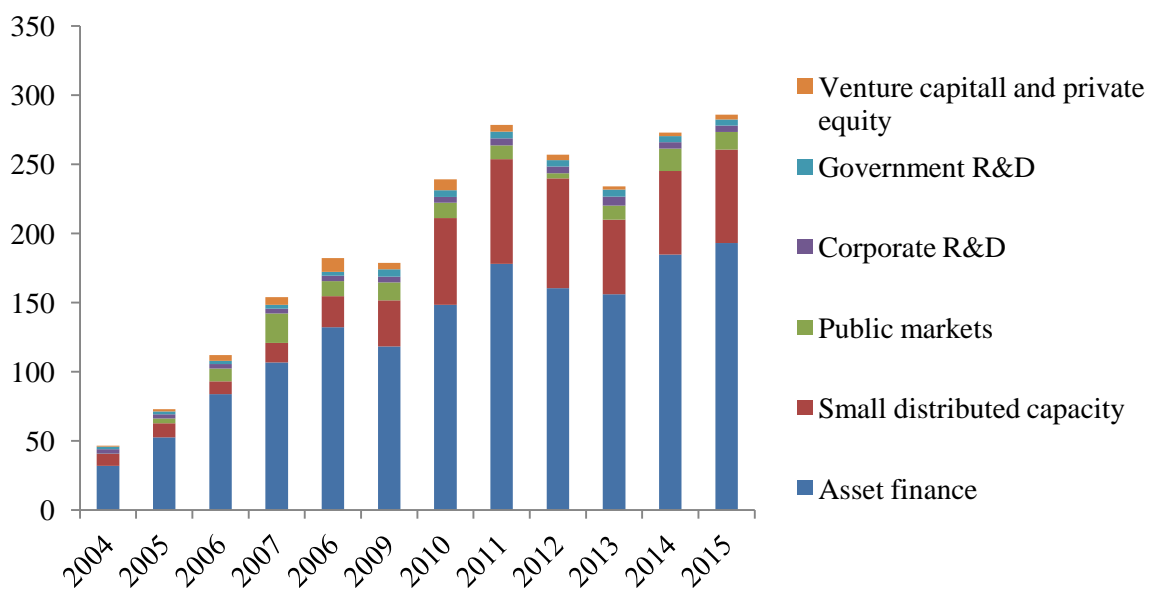


Figure 5: RE investments (ex. large hydropower projects) by asset class, 2004-2015, BN USD (nominal)
 Source: Bloomberg New Energy Finance (BNEF, 2016)

By asset class: asset finances² of utility-scale projects such as wind farms and solar parks remained the largest components of investments and amounts for \$193.21 BN in 2015. Spending on small distributed capacities³ set up \$67.44 BN. Such asset classes as venture capital and private equity⁴ (\$3.40 BN), corporate research and development (\$4.67 BN), government research and development (\$4.38 BN), and public markets⁵ (\$12.81 BN) had the smallest share of investments (see Figure 5).

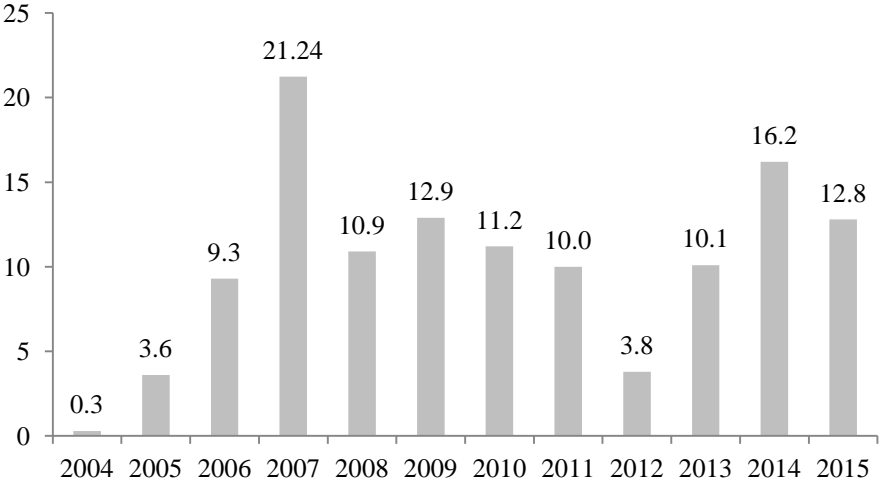


Figure 6: Public investments in RE (ex. large hydropower projects), 2004-2015, BN USD (nominal)

Source: Bloomberg New Energy Finance (BNEF, 2016)

In 2015, public investments in RE, despite of the highest worldwide additions of PV capacity (56GW) and wind (62GW), fell by 21% (see Figure 6). Such trend is explained by a big influence of stock markets' behavior generally, and of the share prices of clean power companies in particular. By sector, public solar investments jumped by 21%. Investments in wind plunged 69%, and that in biofuels halved for the second year running (BNEF, 2016).

While RE public investments were dominated by the US, China overtook the US top position in overall investment in RE (BNEF, 2016). China led the list for 2015 by a large margin, accounting for more than a third of global investments.

² Asset finance: all money invested in RE generation projects (excluding large hydro) whether from internal company balance sheets, from loans, or from equity capital. These include refinancing.

³ Local and rooftop solar projects of less than 1MW capacity.

⁴ Venture capital and private equity (VC/PE) all money invested by venture capital and private equity funds in the equity of specialist companies developing RE technology.

⁵ Public market: all money invested in equity of specialist publicly quoted companies developing RE technology and clean power generation.

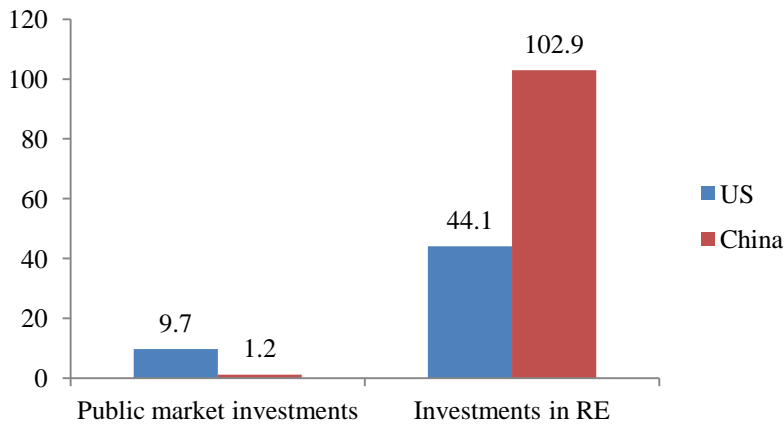


Figure 7: Public market investments and investments in RE (ex. large hydropower projects), the US vs. China, 2015, BN USD (nominal)
 Source: Bloomberg New Energy Finance (BNEF, 2016)

In 2015, by asset category: asset finance and small scaled investments have had the largest share of RE investments in China, with \$95.7 BN and \$5.5 BN respectively (see Figure 7). By sector, offshore wind finally had a breakthrough year in China in 2015, with no fewer than nine projects financed, for an estimated cost of \$5.6 BN. They included three 300MW projects, all with an estimated capital cost of around \$850 million. But the greatest weight of utility-scale financings continued to be in onshore wind, with \$42 BN secured, up 9% on 2014, and in PV, with \$43 BN, up 18% (BNEF, 2016).

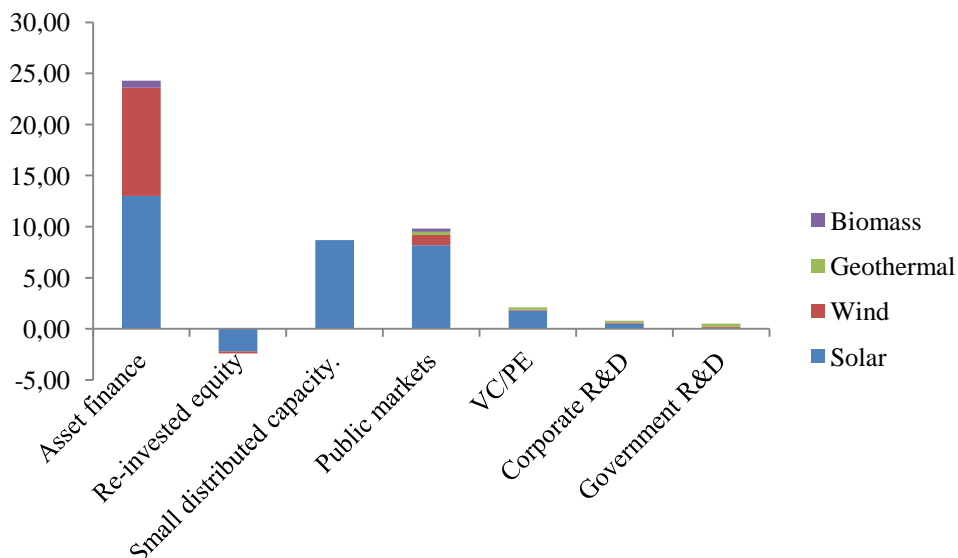


Figure 8: RE investment in the US by sector and type (ex. large hydropower projects), 2015, BN USD (nominal)
 Source: Bloomberg New Energy Finance (BNEF, 2016)

The US remains the biggest investing country in RE in terms of company-level funding. Venture capital and private equity finance for RE reached \$2.2 BN, the share issues for specialist companies on public markets were \$9.7 BN in 2015 (see Figure 8). Asset finance of utility-scale renewable energy projects in the US had the largest share and rose on 31% in 2015, with solar increasing on 37% and wind - on 24%.

2.3 China vs. the US: RE policy and political system

An increasing number and variety of RE policies and regulations have driven growth of RE technology (IPCC, 2011). Government policies play a crucial role in accelerating the deployment of RE technologies. RE policies are designed to stimulate promotion of RE development, and can be categorized into several broad groups: direct and indirect (Dijk et al., 2003), regulatory and economic instruments (Simpson, 2013). The direct approach is aimed at the RE sector, whereas indirect approach is aimed on the outside of the RE sector (Dijk et al., 2003). Regulatory approaches aim to influence directly the behavior of economic agents by setting standards and goals, and enforcing them through command-and-control. Governments use economic instruments to incentivize behavioral changes of the market participants, and, consequently, large scale adoption of RE technologies (Simpson, 2013).

During the last few years, China's central government have put forward various policies for the development of RE, giving a clear policy signals to the capital markets (Ming, Ximei, Yulong, & Lilin, 2014). Policies to encourage RE in China are largely driven by the central government, and enacted through national, provincial, and local government programs (Campbell, 2014).

While a series of programs to promote RE in China were established since 1982⁶, the rapid promulgation of RE policies and regulations has begun since 2005 when Chinese government released "The Renewable Energy Law" (Wang et al., 2010). In accordance with this law, China's government has established main financial arrangements for supporting of RE, such as: tariffs; cost sharing; The Special Fund, which provides grants and subsidies (Donovan, 2015). Various regulations, tariffs and subsidies were established to encourage RE firms to achieve top-down RE targets set by the national government. The China's government has provided financial support to RE development on the different levels of supply chain, primarily emphasizing manufacturing of the RE equipment (Donovan, 2015).

The subsidies and payments to promote the development of RE have increased rapidly. The total amount of RE electricity surcharge and subsidy payments in China for the

⁶ These include: Key Technology R&D Program, 863 Program, and 973 Program (Campbell, 2014)

period of 2006-2009 was 9566.3 million RMB, in 2012 this amount increased to 10435.3 million RMB, and in 2013 payments increased to 25246.3 million RMB (Donovan, 2015). Unquestionably, such high amount of subsidies led to growth in production of RE technologies (Zhao et al., 2014) and increase in RE capacity (IRENA, 2017).

A series of legislation to promote RE⁷ technology in the US started much earlier than in China. Policy interventions in the US can be divided into five separate categories⁸, most of which take the form of financial incentives such as: tax breaks and reductions, loans, rebates, and specific funding etc. (Aslani & Wong, 2014). Such incentives are provided on the different levels of the value chain. According to the US Energy information administration (IEA, 2015), the total amount of the federal subsidies in RE in 2010 was accounted for \$15,642 million with decrease to the \$15,043 million in 2013. Just like in China, US financial incentives led to the increase in installed capacity of RE (IRENA, 2017).

Differences in US' and China's political systems may result in different signals sent to the market participants. In China the central government is the key policymaking body, therefore, market participants focus primarily on the central policies (Lo, 2014). On the other hand, the US federal government, in promoting development of RE, heavily relies on the policies of different states (Campbell, 2014).

During the last years China's central government pushed forward planning and various policies for the development of RE, giving a clear policy signals to the capital markets (Campbell, 2014; Ming et al., 2014). In addition, the central government of China encourages state-owned commercial banks to provide favorable and low-interest debt financing loans for firms engaging in RE development (Ming et al., 2014). China's constitution does not provide for a division of power among the various levels of government. Officially, each successive level of government down from the top reports to the preceding level above it (Martin, 2010).

Some researches (Campbell, 2014; Elliott, 2011; Mendonca et al., 2009) argue that the US does not have an effective and consistent national RE policy, this may confuse market participants. While China's laws and regulations driven mainly by the central government (NPC, 2014), in the US RE policies are driven at both federal⁹ and state levels¹⁰. Thus,

⁷ Key among them are: The National Energy Act of 1978; The Energy Security Act of 1980; The Energy Policy Act of 1992; The Energy Policy Act of 2005; The Energy Independence and Security Act of 2007; The American Recovery and Reinvestment Act of 2009 (Campbell, 2014); US Climate Action Plan of 2013.

⁸ Those are direct expenditures to producers or consumers, tax expenditures, research and development, federal electricity programs supporting federal and rural utilities, loans and loan guarantees.

⁹ The main incentives on the federal level are: Investment Tax Credit (ITC); Production Tax Credit (PTC); Clean Power Plan; Modified Accelerated Cost Recovery System Depreciation Schedule; Doe Loan Program (Zhou, 2015).

individual states may have renewable electricity mandates. In contrast to the situation in China, much of the US electricity installed capacity is a result of state deployment initiative rather than federal programs, with 30 states having a renewable portfolio standard (RPS) in place to encourage RE deployment (Campbell, 2014).

Unlike politics of China which is run by a single party - the Communist Party - a much more typical situation in the US is the "divided government", with different political parties (and fractions within the parties) in control of different parts of the government (Elliott, 2011). In addition, the US policy is characterized by shifting policies and changing priorities, and the policies in the US tend to "come and go" (Mendonca et al., 2009).

An example of the "shifting policies" is the US policy to promote an alternative to gasoline-powered automobiles. In 2003, then President G. W. Bush announced an initiative to devote billions of dollars to develop the hydrogen-powered fuel cars. In 2008, then President Obama cuts 80% of the funding for the hydrogen car, and in 2011, he announced the promotion of electric-powered car instead (Elliott, 2011).

In addition, the policies in the US tend to "come and go". Scholars argue that the only thing consistent with US policy is its inconsistency (Mendonca et al., 2009). The notable example of policy inconsistency is US tax credits. In 1992 the Production Tax Credit (PTC) of 1.5 cent/kilowatt-hour (kWh) of electricity was created for large-scale wind projects. In 1999, the PTC was allowed to expire for the first time, causing a 93% drop in wind development the following year. The PTC was also allowed to expire in 2001 and 2003, resulting in a more than 70% drop in development in 2002 and 2004 (Mendonca et al., 2009).

Another example is the Investment Tax Credit (ITC) which was established in 1978. In the period from 1986 to 1988, it was reduced to 10% for solar. In 2005, the residential and business ITCs were raised to 30% and extended for 3 years, resulting in a doubling of installed PV capacity in the US (Mendonca et al., 2009).

At the end of 2013, PTC and ITC lapsed and were reinstated for just two weeks in mid-December 2014. Then, they were unavailable for almost the whole 2015, and not expected to be revived, perhaps ever. However, a deal on general government funding on Capitol Hill in December 2015 surprisingly included a clause extending the PTC and ITC for a full five years (BNEF, 2016).

¹⁰ In addition state-level drivers to the RE are: Renewable energy Certificates or Performance Based Incentives; Net Metering; Virtual Net Metering; Carbon Markets; State Tax Credit; Property Assessed Clean Energy; Property Tax Exemptions; State Sales Tax Exemptions, Grants; Clean Energy Financial Program; Subsidized Loans; On-Bill Financing (Zhou, 2015).

For the envisioned sustainable growth of the RE sector, important success factors are not only effectiveness of policy, but also security for investors, which is essential for building up a sector and developing the RE market. Consistency of regulations and policies at different levels form a condition for security, as does the active involvement of market stakeholders (Dijk et al., 2003).

To sum up, different political systems may affect the energy industry differently. In particular, one may hypothesize that policy signals in a more centrally planned economy such as China are more credible and therefore have a greater impact on stock prices of energy firms, compared with countries with more divided and heterogeneous governments, such as the US.

3 Theory

3.1 Efficient market

The stock market movement is among the most studied phenomenon within economics and finance. The central question has been to find out which factors have an impact on stock returns. In this chapter, I review the most relevant theories of stock pricing. I start with an overview of the Random Walk Hypothesis (RWH) and Efficient Market Hypothesis (EMH), before explaining the link between political events, government policy, and stock market.

Much of the literature on stock pricing revolves around the RWH and the sub-martingale property (Fama, 1965, 1970, 1995; LeRoy, 1973). Markets is said to follow a random walk, if changes in asset prices occur randomly, because asset prices already reflect all available information. This means that prices changes should be random and unpredictable. Randomly evolving stock prices is a consequence of intelligent investors' competition. They try to discover relevant information on which to trade the stock before the rest of the market becomes aware of that information (Fama, 1995).

Stock prices is said to follow a sub-martingale, meaning that the expected change in market price can be positive, presumably as a compensation for the time value of money and systematic risk (Bodie et al., 2011). The price sequence p for security j follows a sub-martingale with respect to the information sequence Φ if the expected value of next period's price equal to or greater than the current price in equation 2 (see below):

$$E(\tilde{p}_{j,t+1}|\Phi_t) \geq p_{j,t}, \quad \text{or equivalently, } E(\tilde{r}_{j,t+1}|\Phi_t) \geq 0 \quad (1)$$

The RWH is more restrictive than sub-martingale properties. In general, the RWH requires that successive price changes are independent and identically distributed (Fama, 1970), and implies that a series of stock price changes has no memory (Fama, 1995). Hence, the past history of the prices cannot be used to predict the future price change.

While it is unlikely that the RWH provides an exact description of the behavior of stock market prices, according to the Fama (1995) model may be acceptable, for practical purposes, even though it does not fit the facts exactly. Thus, although successive price changes may not be strictly independent, the actual amount of dependency may be so small as to be unimportant, i.e. independence assumption of the random walk model is valid as long as knowledge of the past behavior of price changes cannot be used to increase expected gains (Fama, 1995).

An "efficient" market is defined as a market where there are large number of rational, profit-maximizers, who actively compete with each trying to predict future market values of individual securities (Fama, 1991). In an efficient market, important information is freely available to all participants and at any point in time the actual price of a security will be a good estimate of securities' intrinsic value (Fama, 1970).

In the efficient market stock prices "fully" and "instantaneously" reflect all available information (Fama, 1970, 1995). In this context one must define the term "fully reflect". Fama (1970) posited that conditional on relevant information set of the equilibrium expected returns can be derived as follows:

$$E(\tilde{p}_{j,t+1}|\Phi_t) = [1 + E(\tilde{r}_{j,t+1}|\Phi_t)]p_{jt} \quad (2)$$

where p_{jt} is the price of security j at time t ; $p_{j,t+1}$ is its price at time $t+1$ (with reinvestment of any intermediate cash income from the security); $r_{j,t+1}$ is the one-period percentage return; Φ_t is a set of information, that is assumed to be "fully reflected" in the price; and the tildes indicate that $\tilde{p}_{j,t+1}$ and $\tilde{r}_{j,t+1}$ are random variables.

The conditional expectation notation implies that the information is fully utilized in determining equilibrium expected returns. In this sense the information set is "fully reflected" in the formation of the price (Fama, 1970). In addition, Fama (1995) argues that in an efficient market on average the competition will cause full effects of new information on intrinsic values to be reflected "instantaneously" in actual prices.

Fama (1970) categorized market efficiency into the three forms: the weak form, semi-strong form, and strong form. In the weak form the information subset of interest is just past price (or return) histories. The semi-strong form concerns on the speed of price adjustment to other obviously publicly available information. The strong form concerns in monopolistic access an investor or group may have to relevant information to the formation of prices.

The efficient adjustment of prices to new information depends on the market conditions. Emerging markets, for example, that are less extensively analyzed than old markets (such as in the US) may be less efficient (Bodie et al., 2011). Hence, Fama (1970) provides conditions of the market that could either hinder or help market efficiency. The examples of conditions for capital market efficiency are: (1) there are no transactions costs in trading securities, (2) all available information is costless and available to all market participants, and (3) all agree on the implications of current information for the current price and distributions of future prices of each security. In such a market, the current price of a security will "fully reflects" all available information.

Nevertheless, a frictionless market in which all conditions hold, of course, not descriptive of markets met in practice. In this Fama (1970) argued that the market may still be efficient if "sufficient numbers" of investors have ready access to available information. In addition, disagreements among investors about the implications of the new information does not in itself imply market inefficiency, unless there are investors who can consistently make better evaluations of available information that are implicit in market prices. Thus, transactions costs, information that is not freely available to all investors and disagreement among investors about the implications of given information just a potential, but not necessary sources of market inefficiency.

On the other hand, the definitional "fully" suggests that no real market could ever be efficient, implying that the EMH in its most literal interpretation is false. Indeed, if financial markets really are efficient, an investor who has picked a brilliant investment could only have done so by blind luck. Neither can anyone predict what the market will do in the future, because efficient markets already reflect all available information. Thus, neither technical analysis nor fundamental analysis would be able to achieve returns greater than those that could be obtained by holding a randomly selected portfolio of individual securities (Bodie et al., 2011).

Thus, not surprisingly, the EMH got a lot of critique among scholars, and does not arouse enthusiasm in the community of the professional portfolio managers (Bodie et al., 2011). Bernstein (1999), for example, criticized the EMH and claimed that that fact that

thousands of market participants spend much time in gaining access to new information, on evaluating the information, and in translating the information into investment decisions suggest that the marginal benefits of acting on information exceed the marginal costs. He argued that this is inconsistent with the minimal marginal benefits set by the efficient markets hypothesis. In this context, he concluded that either the EMH has an inherent flaw, or investors are totally irrational.

Shleifer (2000) in his book "Inefficient Markets: An Introduction to Behavioral Finance" questioned the assumptions of investor rationality and perfect arbitrage, and states that systematic and significant deviations from efficiency are expected to persist for the long period of time. He challenges the EMH, demonstrating that markets cannot be explained historically by the movement of company earnings or dividends.

Some scholars argue that the market has been caught in speculative bubbles (Abolafia & Kilduff, 1988; Shiller, 2000, 2002). Shiller (2000), for example, argues that as people go through waves of optimism or pessimism for their own economies, there appeared to be unseen speculative bubbles in unobserved prices.

Nevertheless, in this thesis I focus on the semi-strong form of the EMH, which postulates that market stock prices reflect the announcements of all public information without biases (Fama, 1991). The semi-strong form of market efficiency deals with how quickly prices reflect public information and specifically evaluates the effect of an event on the market return (Dangol, 2008).

Some scholars analyzed the effect of different kinds of public announcements, and most of them support the semi-strong form of market efficiency (Ball & Brown, 1968; Fama, 1970). Fama (1970) argued that there is no important evidence against the weak and semi-strong forms of market efficiency. He argued that prices seem to efficiently adjust to obviously publicly available information.

Thus, any relevant new public information should be reflected in the stock price adjustment. In, this any news about changes in the government and announcements about RE policy will be reflected in the price changes. Following this line of reasoning, I should be able to measure the importance and anticipation of political events and news about RE policy by examining price changes during the period immediately after the event occurred (Bodie et al., 2011).

3.1.1 Anticipation and relevance

According to the EMH any relevant new public information should be reflected in the stock prices. The two main issues that I want to discuss are anticipation and irrelevance of the information.

The information is often said to be the most precious commodity for many investors, and the competition for it is intense. An efficient capital market sets prices based on expectations of the future, and it is often difficult to identify when the market participants changes their expectations. Especially, it applies to the slowly occurring events such as legislation process, because of difficulty to determine the date of actual occurring of an event. New laws are discussed before they are actually introduced and there is a considerable period of debate. Regulatory events usually involve multiple announcements, and are more likely to be anticipated than corporate announcements, due to extensively negotiations (Binder, 1985a). Kothari and Warner (2004) showed that if the event is partially anticipated, some of the prices behavior related to the event should show up in period preceding the event.

The suggestion to use asset prices to measure the effect of regulation on producer profit was made by Schwert (1981), while Binder (1985a) showed that stock returns are not very useful in studying regulations' effectiveness, due to its anticipation. Nevertheless, the analysis of the impact of government regulations on the stock returns is an increasingly popular topic of research (Bernanke & Kuttner, 2005; Ramiah et al., 2015a, 2015b; Schwert, 1981). To circumvent the problem of date uncertainty Schweitzer (1989) proposes to look at an event "window" framing the possible event date within a period of several days. Dyckman, Philbrick, and Stephan (1984) found that testing cumulated excess returns over a slightly longer period allows a researcher to detect events without precisely pinpoint the timing of the event. Li and Prabhala (2005) provides appropriate procedures for treating self-selection and partial anticipation issues.

In addition to novelty, the information should be relevant. There is a broad consensus (Aslani & Wong, 2014; IPCC, 2011; Kaminker & Stewart, 2012) that the RE policy is effective in stimulating the development of RE technologies and increase investments in RE development. Nevertheless, while the RE laws and regulations are relevant to RE industry, the relevance of a single announcement made by government about future RE policy is questionable.

When a government announces future policy the question of the market participants is the likelihood of that announcement to happen (especially in the countries with divided

powers). Market participants may not perceive news about possible future policy as a binding commitment. In the US, for example, a strong wing of one of the two major political parties is generally opposed to government actions to promote renewables (Elliott, 2011), this can undermine the future policy legislation.

To sum up, to change market participants' expectations it is necessary that government announcements about future RE policy contain major new information (Binder, 1985a) and that information is relevant. Relevant and unanticipated information will be reflected in stock prices on the actual day of policy announcement. Nevertheless, failure to detect the effect on stock prices is due to irrelevance or anticipation, or both, and it is hard to determine which of the two factors can explain a non-significant effect on stock.

3.2 Stock market and political events

The literature that links political events and financial markets are growing (Booth & Booth, 2003; Dangol, 2008; Foerster & Schmitz, 1997; Kabiru et al., 2015; Murtaza, Haq, & Ali, 2015; Zach, 2003). Such events as general elections (Kabiru et al., 2015), news regarding the peace process in the Middle East (Zach, 2003), international conflicts (Schneider & Troeger, 2006), climate change and environmental events (Beatty & Shimshack, 2010; Deak & Karali, 2014), and disasters (Capelle-Blancard & Laguna, 2010) influence stock market.

Presidential elections influence the performance of firms through future policy of the new government. A key role of presidential elections belongs to uncertainty about government and its policy (Pastor & Veronesi, 2012). There are two types of uncertainty. The first type is political uncertainty, which relates, for example, to uncertainty about whether the current government will change. The second type is policy and regulatory uncertainty, which corresponds to uncertainty about future government policy and regulations (Gatzert & Vogl, 2016).

Pastor and Veronesi (2012) investigated the effect of uncertainty about governmental policy on stock prices. They have found that uncertainty about what the government is going to do negatively affect stock prices. Booth and Booth (2003) investigated the effect of the US presidential cycle on large-cap and small-cap stock returns. They found that returns depend on the political party which was in power, with higher returns on fixed securities when the ruling party was republican. Foerster and Schmitz (1997) analyzed the effect of US election cycles on international returns; stock return from eighteen OECD countries followed a pattern consistent with US presidential cycle. They, therefore, concluded that US presidential cycles are important in determining international stock risk premium market.

The challenges and opportunities to industry from climate change and environmental events (Beatty & Shimshack, 2010; Deak & Karali, 2014; Konar & Cohen, 2001), and disasters (Capelle-Blancard & Laguna, 2010) are large. Climate change influences the demand and supply of electricity through changes in temperature, precipitation, wind speed, extreme weather and sea level rise (Mideksa & Kallbekken, 2010).

Most studies have found evidences that stock prices declines in response to negative environmental news and increases in response to positive environmental news (Deak & Karali, 2014; Hamilton, 1995; Klassen & McLaughlin, 1996; Konar & Cohen, 2001). Deak and Karali (2014), for example, in their study of the effect of environmental news on the performance of firms in food industry found that positive environmental news lead to a higher predicted returns, whereas negative to lower.

In this connection, I have chosen three political events which I expect will affect the performance of RE and fossil firms. These are: the 2012 presidential election in the US, the 2015 Paris agreement on climate change, the 2016 presidential election in the US.

The first event occurred on the 7.November 2012 when President Barack Obama was re-elected. First, during his first term, Barack Obama clearly advocated RE sources. He was associated with the series of green policy initiatives, such as: The New Energy for America plan, introduction of cap-and-trade-system, the clean energy funds, proposal of new offshore drilling (Ramiah et al., 2015b). The New Energy for America plan, for example, was designed to promote RE. This plan concentrated on investments in RE, addressing the global climate crisis, and setting a goal to make a coal less competitive energy source.

Second, the fossil fuel industry is particularly vulnerable to environmental regulations, which Obama pushed during his first term (Norris & Schwartz, 2012, November 7). Experts argued that a second Obama term would most likely make coal exploration and combustion more expensive (Farrell, 2012, November 7).

Despite that fact that Obama clearly promoted renewable energy technology, on the day after the election stock market crashed (Farrell, 2012, November 7). Shares of PowerShares WilderHill Clean Energy Portfolio (PBW), for example, sold-off. Nevertheless, it is of interest to observe how particularly US and Chinese firms reacted to the event, and whether the reaction is statistically significant.

Thus, I put forward the following hypothesis:

H1: US RE companies reacted positively to the Obama's re-election, and fossil fuel companies experienced a negative effect.

The next event is the Paris Agreement of the UNFCCC (United Nations Framework Convention on Climate Change), adopted on 12. December 2015. The Paris agreement marks strong commitments of countries to the climate protection, and many observers argued that the agreement signaled "a turning point" in the road to a low carbon society (Keane, 2015, December 12; Milman, 2016, October 5), and an "end to the fossil fuel era" (Goldenberg et al., 2015, December 12). The deal puts into the agreement the countries' pledges submitted to the United Nations to stop the growth of GHG, mainly from burning fossil fuels (Goldenberg et al., 2015, December 12). Sandalow et al. (2016) surveyed the market signals of the Paris agreement. They argue that the agreement has a potential and significant influence on climate finance, including private sector financial.

Thus, RE firms would expect to see big upticks in investments to develop new technologies, while coal and oil companies would expect tougher regulations (Kar-Gupta et al., 2015, December 14). At the same time, the deal could be viewed as a signal to global financial and energy markets, triggering a fundamental shift away from investment in coal, oil and gas as primary energy sources toward zero-carbon energy sources like wind, solar and nuclear power (Davenport, 2015, December 12).

On the other hand, both relevance and anticipation of the agreement can be questioned. The previous major agreement on climate change – the Kyoto Protocol of 1997 – lost much of its credibility as by 2010 a number of signatory-countries failed to meet their targets. Further, the Kyoto Protocol only covered the so-called Annex I (developed) countries with legally binding emission targets, while carbon emissions from non-Annex I countries, such as China and India, and from non-signatories such as the US continued to grow (Griffin, 2009). In this connection, the credibility of the Paris Agreement could be questionable in the sense that while countries pledge to decrease GHG emission (especially from burning fossil fuels) such commitments may not be met. The questions are how large future Intended Nationally Determined Contribution (INDCs) – a cornerstone of the Paris Agreement – will be and whether they will be implemented at all. So far they are well below what is needed to get on track towards a 1.5 or 2 degree target.

In addition, Paris agreement was not the first time when the US and China cooperate to stabilize or decrease GHG emissions. In the November 2014 the US and China jointly announced their aims to combat climate change. Then President Barack Obama announced that the US intended to achieve an economy-wide target of reducing its emissions by 26%-28% below its 2005 level in 2025. President Xi Jinping announced that China intended to achieve the peaking of GHG emissions around 2030, and increase the share of non-fossil fuels

in primary energy consumption to around 20% by 2030.¹¹ Thus, both countries pledged to decrease GHG emission even before the Paris agreement. Thus, the importance of the Paris agreement to change policy of each country is also questionable in the sense that while it signals a "a turning point" in the road to a low carbon society, the two biggest polluters have started to on that road quite long before the Paris accordance actually took place.

In addition, the Paris agreement can be categorized as a slowly occurring event with a long period of the negotiations between countries about climate change, which received big coverage by media and analyst (Stokman & Thomson, 2015). Thus, the outcome of the agreement could have been fully anticipated.

Nevertheless, the overall movement of the market on the 14.December 2015 indicated the significance of the Paris agreement. Share prices of fossil fuel companies dropped, while of RE stocks surged. The MAC Global Solar Energy Index was up 1.9%. The iShares Global Clean Energy Exchange Traded Fund rose 1.4%. The US Oil & Gas Index dropped on 0.5%. Shares of companies that produce coal sink the most (Kar-Gupta et al., 2015, December 14).

Thus, my aim is to evaluate the impact of the Paris Agreement on the performance of energy firms specifically in the US and China. By now, I put forward the following hypothesis:

H2: RE firms reacted positively to the Paris agreement of 2015, while fossil firms experienced a negative effect.

The last event is 2016 presidential election in the US. During Donald Trump's presidential campaign, he repeatedly said that he would abolish the Environmental Protection Agency (EPA), abandon the EPA's Clean Power Plan, pull out of the Paris agreement, and boost coal and natural gas (Ritchie, 2016, December 1). Trump's pre-election statements on fossil fuels and RE were clear. Bouoiyour and Selmi (2017), for example, argues that the Trump's victory divided the US stock market into two main groups: winners and losers.

Hence, I hypothesize that the 2016 presidential election in the US affected stock prices of RE firms negatively and fossil firms positively.

¹¹ <https://obamawhitehouse.archives.gov/the-press-office/2014/11/11/us-china-joint-announcement-climate-change>. Released: November 11, 2014. Extracted: 25.04.2017

H3 (a): US RE firms reacted negatively to the US 2016 presidential election and fossil firms reacted positively.

H3 (b): The election affected Chinese firms.

3.3 RE policy announcements and stock market

There is a large literature which investigates the impact of policies on the stock market (Bernanke & Kuttner, 2005; Pastor & Veronesi, 2012; Ramiah et al., 2013; Ramiah et al., 2014; Ramiah et al., 2015a). Government use laws and regulations to affect firms: they levy taxes, provide subsidies and investments, enforce laws, regulate competition, etc. First, new policy changes the market participants beliefs (Pastor & Veronesi, 2012). Second, changes in laws and regulations can influence the way firms operate and, thus, affect firms' earnings (Schweitzer, 1989).

RE policies are designed to stimulate investments in RE. Subsidies and tariffs, for example, give a competitive advantage to the industry. In the case of subsidies, the government gives money to a selected industry to make it more profitable. In the case of tariffs, the government applies taxes to foreign products to make them more expensive, allowing the domestic suppliers to charge more for their product. Both of these actions have a direct impact on the market (Beattie, n.d.).

Scholars (Couture & Gagnon, 2010; Jenner et al., 2013; Polzin et al., 2015) have recognized that financial incentives spur deployment of RE technologies, provide short-term and long-term financial relief for RE projects, and lower risks associated with RE technologies for private actors (Polzin et al., 2015).

Thus, I hypothesize that news about RE policy affect RE sector:

H4: News about RE policy affected RE firms positively

Now the question here is whether announcements about RE policy are also relevant to the fossil fuel sector. The effect of RE policy on fossil firms is not clear-cut. On the one hand, the effect could be negative, because of the world's transition to the RE and subsequent investors' resource reallocation. On the other hand, the world's energy market is still dominated by fossil fuels (OECD, 2012), and given such dominance, they will remain the

backbone of the world's energy system for all foreseeable time (Höök & Tang, 2013; Salameh, 2003).

There are several main issues with present energy system: depletion of fossil fuel reserves, global warming, energy security concerns and rising energy costs (Asif & Muneer, 2007; Dijk et al., 2003). There is a large literature on predictions of when supply of fossil fuels will be exhausted (Asif & Muneer, 2007; Day & Day, 2017; Höök & Tang, 2013; Shafiee & Topal, 2009) and whether RE sources can substitute fossil fuels.

Asif and Muneer (2007), for example, provides a projection of energy scene for five countries India, China, Russia, UK, and US, and quantifies the period of exhaustion of the major energy sources, i.e. coal, oil, and gas. They predicted the exhaustion of coal for India, China, Russia and US to be about 315, 83, 1034 and 305 years, respectively. Shafiee and Topal (2009) presented a new formula for calculating when fossil fuel reserves are likely to be depleted and develops an econometrics model to demonstrate the relationship between fossil fuel reserves and some main variables. They projects the fossil fuel reserve depletion times for oil, coal and gas of approximately 35, 107 and 37 years, respectively. The World Coal Association (Day & Day, 2017) estimated that at current extraction rates, proven coal and oil reserves worldwide could last around 110 and 50 years, respectively. Höök and Tang (2013) in their study on the depletion of fossil fuels and its impact on climate change, argues that given the dominance of fossil fuels, they will still remain the backbone of the world's energy consumption.

Governments around the world promote RE to replace fossil. Blottnitza and Curran (2007) estimated that the potential for ethanol production is equivalent to about 32% of the global gasoline consumption, and could replace 353 gallons (GL) of gasoline when used in E85 (85% ethanol in gasoline) for a midsize passenger vehicle. Lund (2007) discussed the problems and perspectives of converting present energy systems into a 100% RE system in Denmark. The author argues that such development is possible after overcoming three key technological changes. Those are: (1) oil for transportation must be replaced by other sources; (2) include small combined heat and power (CHP) plants in the regulation as well as adding heat pumps to the system; and (3) to add electrolyzers to the system and provide a further inclusion of wind turbines in the voltage and frequency regulation of the electricity supply. Salameh (2003) studied whether RE can fill the global energy gap in the 21st century. He shows that even though a transition from fossil fuels to renewable energy sources is inevitable, the fossil fuels will still be supplying the major share of the global energy needs for most, perhaps all, of the 21st century. Höök and Tang (2013) in their study on the depletion of

fossil fuels and its impact on climate change, argues that given the dominance of fossil fuels, they will remain the backbone of the world's energy system for all future.

There are other issues with RE sector, such as industrial overcapacity and under-deployment of RE technology (Ming et al., 2013; Peidong et al., 2009; Wang, 2010), inconsistency between wind farms development and grid planning (Luo, Zhi, & Zhang, 2012), mismatch between energy policy and industrial policy (Zhang et al., 2013), and intermittency of RE generation (Turner, 1999).

Thus, the question is whether RE is a significant competitor to the fossil fuels. Given that fossil fuels will be dominant up to 2050, and there are still a lot of problems to overcome to transit towards a low-carbon society, I hypothesize, that:

H5: The performance of fossil firms was *not* affected by the news about RE policy.

3.4 Does political system matter?

Recall my discussion about the issues of anticipation and relevance of the information provided in the sub-chapter 3.1.1. US government announcements about future RE policies might be more anticipated than the Chinese, due to a more open political system. In addition, the US RE policy could be less relevant than the Chinese due to changing priorities of the US government and heavy reliance of the US federal government on state-level policies, as have been discussed in the background.

Thus, I hypothesize that:

H6: Chinese RE policy announcements had stronger effect on the performance of RE firms than US policy.

3.5 Empirical studies on the effectiveness of green regulations

The purpose of this section is to show the evolution of the relevant literature by illustrating empirical studies provided on the effectiveness of green regulations in general and in China and the US in particular.

The effect of green regulations (which include RE policy) on the investments in RE has been extensively analyzed and is not a new topic. Polzin et al. (2015) investigated the impact of public (green) policy on investments in RE across OECD countries. As a result of their study they call for technology specific policies which take into account actual market conditions and technology maturity. Eyraud et al. (2013) studied the trend and determinants of

green investments (GI) over the period of 2000-2010 for 35 countries, and the impact of green policy on GI. They have found that not all public interventions are successful in boosting GI. Romano et al. (2017) showed that effectiveness of green policies depends on the stage of development of the countries. Meyer and Koefoed (2003) investigated the impact of wind promotion policy on investors in Denmark and found that changing in wind promotion policy caused wind industry to stall. The general results from such studies are: not all green policies are effective in promotion RE investments; policies should differ across countries and be specific to the source of energy.

Studies that examine the effectiveness of RE policies specifically in China (Ming et al., 2013; Peidong et al., 2009; Wang, 2010; Zhang et al., 2013) and the US (Aslani & Wong, 2014; Campbell, 2014; Delmas & Montes-Sancho, 2011; Elliott, 2011; Ramiah et al., 2015b) show mixed results. Thus, Zhang et al. (2013), for example, argued that, while China's policy approach has driven a rapid increase of wind and PV manufacturing industries, it has led to the industrial overcapacity and under-deployment of RE. Other problems with China's policy are lack of enforcement of regulations and poorly designed policy instruments (Ramiah et al., 2015a). Researchers (Luo et al., 2012; Zhang et al., 2013) have identified several important barriers for the RE sources. Such barriers are the inconsistency between wind farms development and grid planning and the mismatch between energy policy and industrial policy.

Aslani and Wong (2014) argued that most of the growth of RE electricity generation in the US is a result from state renewable portfolio standards requirements and federal tax credits. Delmas and Montes-Sancho (2011) showed the positive and significant effect of some of the US RE policies. Thus, Campbell (2014) argued that the US does not have a single and comprehensive national RE policy that promotes RE technologies. Elliott (2011) argued that frequent changes in governmental control by the US political parties and the "shifting policies" result in the major difficulties in promoting RE technology. In addition, Ramiah et al. (2015b) in their event study showed that during the period of 1997-2008 environmental-friendly industries have been unresponsive to announcements of environmental regulations.

4 Data and Methodology

4.1 Data

I use daily stock prices, adjusted for dividends and splits, of 68 RE and fossil fuel firms (see A.1 for complete list of companies included in the study).¹² There are 33 RE

¹² finance.yahoo.com and NASDAQ.com.

companies and 35 fossil fuel companies in the sample. All of these firms are publicly-listed entities on the NYSE/AMEX or Nasdaq for the period of January 2011 and December 2016. To measure the impact of news about RE policy I have sourced firms by several criteria: 1) many RE firms work within both RE and fossil fuel sector. To be a RE firm, a firm should have its main business within RE technology (or not to have business in fossil fuel at all); 2) stocks of each firm should be traded on the everyday basis; 3) I use a method that requires prices to be available 1 year before the actual study, thus, the prices for the firms should be available at least from 2011.

I use the S&P 1200 index as a measure for market portfolio, which is downloaded from S&P Dow Jones Indices.¹³

I recode prices into logarithm of the daily return data to improve the normality of the return distribution. In 1976 Fama (Henderson, 1990) suggests that continuously compounded returns conform better to the normality assumptions underlying regression. In addition, a large proportion of the event studies use continuously compounded returns (see e.g. Murtaza et al., 2015; Ramiah et al., 2014; Ramiah et al., 2015a, 2015b). Nevertheless, it is important to note that when the returns are small the log return is approximately equal to the return (Alexander, 2008).

That fact that I have sourced firms by aforementioned criteria gives a small sample size. Thus, stock prices for many firms, for example, such as SolarCity Corporation or Sunrun, are available just after 2012, and are not in the sample. In addition, firms which have diversified products, such as natural gas, oil, and RE sources are taken in the sample just if such diversification is negligible or absent at all. This is done because such diversification of products makes it impossible to isolate the effect of political events and news about RE policy on RE firms.

Trying to isolate the effect of political events and policy announcements on the RE firms, I subdivided US RE firms into two groups. The first group - RE - consists of firms which have all forms of RE except biofuels. The second group - biofuels - consists of firms that produce biofuels. Such division can be explained by the fact that firms which produce biofuels typically have diversified product lines, e.g., they are also involved in grain and food production.

The second component of the dataset is news about RE policy. I examine 68 RE policy news, which are listed in the Appendix (see A.2). They are identified from institutional and

¹³ <http://us.spindices.com/>

government's official websites, and press agencies.¹⁴ The news sourced in the way that there are no firm-specific announcements, such as earnings announcements, announcements about executive changes, dividends and splits (Cannella & Hambrick, 1993; Konchitchki & O'Leary, 2011) on the same day of the news about RE policy. Nevertheless, the US fossil firm-specific announcements could be on the same day as policy news; this is done because the effect of firm-specific announcements will be mitigated due to the sample size.

The initial size of news and announcements was 165, but the number was reduced by three criteria: (1) announcement should not be on the same day as aforementioned firm-specific announcements; (2) all announcements which were described as "expected" in the news were deleted; and (3) the announcement should be made by the government official, e.g., President or Energy department. Further, the sample consist of only *good* news to the RE sector, this is done because China's announcements about RE policy are mainly good up till 2015. Just recently China began to decrease financial incentives, e.g., reduction of feed-in tariffs (Yeung et al., 2016).

4.2 Methodology

The notion of informational efficient market led to a powerful research methodology, i.e. an event study (Aktas et al., 2007; Binder, 1985b, 1998; Brown & Warner, 1985; Campbell & Wesley, 1993; Corhay & Rad, 1996; Dyckman et al., 1984; MacKinlay, 1997; Savickas, 2003; Schweitzer, 1989). The event study methodology is commonly used to evaluate a reaction of the market participants to different events. These events can include earning announcements, the issuing of new debt or equity, government/central bank announcements, and mergers and acquisitions.

There are several main steps in providing an event study: (1) to define the event of interest; (2) to select firms to be included to the study; (3) to measure normal returns; and (4) to measure and test abnormal returns (AR). In the previous chapter I have discussed the first two steps. In this chapter I will discuss the third and fourth.

The normal return is the firms' return in the absence of the event (Schweitzer, 1989). The estimation of the parameters for the normal performance model is done over an estimation window, which is a period before the event window (see Figure 9).

In order to measure the normal performance a time horizon for an event study should be divided into windows. These windows include the estimation window (pre-event), the

¹⁴ US Energy Department, National Committee on US-China relations, China daily, China Business Review, The New York Times, Bloomberg.

event window and the post-event window. Define $\tau = 0$ as the event date, $\tau = T_1 + 1$ to $\tau = T_2$ represents the event window, and $\tau = T_0 + 1$ to $\tau = T_1$ constitutes the estimation window. Let $L_1 = T_1 - T_0$ and $L_2 = T_2 - T_1$ be the length of the estimation window and the event window, respectively (MacKinlay, 1997).

The timeline sequence is illustrated in the Figure 9.

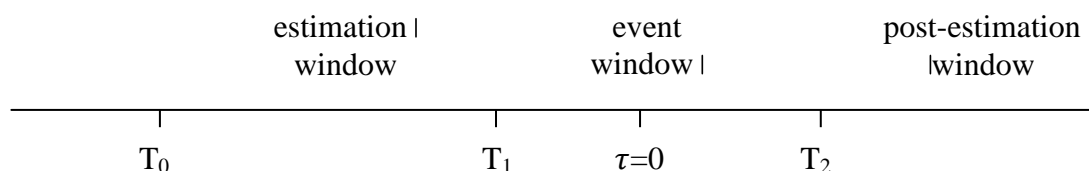


Figure 9: Time line for the event study
Source: (MacKinlay, 1997)

Abnormal returns (or excess returns) represent the firms' returns after subtracting out returns attributed to overall stock market's movement (Schweitzer, 1989).

There are several models that can be used to provide event study and to measure AR, e.g. mean return model, market model, and economic models such as CAPM. In this study I use the market model. MacKinlay (1997) argued that the market model removes the proportion of the returns that is related to the variation in the markets return, thus, the variance of the abnormal returns will be reduced. This can increase the ability to detect the effect of an event. In addition, the use of CAPM in the event study has almost stopped, because the results of the studies may be sensitive to the specific CAPM restrictions. This potential sensitivity can be avoided by using market model.

I use several methods and tests to estimate the effect of policy announcements and political events: (1) market model with abnormal returns (AR) measured as residuals, and Corrado's rank test, (2) I provide multivariate analysis-of-variance (MANOVA) to test for joint significance of no effect of an event, and use multivariate regression model (MVRM) to obtain coefficients for each of the predictors; and (3) panel data model with Driscoll-Kraay standard errors. The choice of these models and tests is justified by the statistical properties of the data, i.e. non-normality and cross-sectional dependence. Further, I discuss each model separately.

I use tests obtained from MANOVA and from panel data model with Driscoll-Kraay standard errors because of the issues with event date clustering. Market model with AR measured as residuals assumes that the residuals are independent and identically distributed

(Binder, 1985b). Nevertheless, residuals will not be cross-independent, because most of the events occur during the same time period (clustering) and firms are within the same or related industries (Brown & Warner, 1985; Campbell & Wesley, 1993). As a proof, I provide Breusch–Pagan test as test for the independence of residuals and Pasaran CD test for cross-sectional dependence. As seen from the Appendix (A.5) both tests give the same results, they are significant, so the residuals are not independent of each other.

In addition, one of the issues of using daily stock returns is that individual security exhibit departure from normality. Brown and Warner (1985) showed that the same holds for the mean excess returns. Thus I provide Shapiro-Wilk test for normal data for estimates for event date "0", the results of the test are listed in the Appendix (A.5). In particular, the null hypothesis of the test is that the data is normally distributed. If $p > 0.05$ we cannot reject the null hypothesis (on 5% level).

4.2.1 Market model with abnormal returns measured as residuals

First, I estimate the effect of political events on firms' performance. I use market model and obtain averaged AR measured as residuals (for more information of the aggregation of AR see A.3). To deal with non-normality in AR and cross-sectional dependence, I use Corrado's rank test (see A.4) to test for statistical significance. Campbell and Wesley (1993) showed that the non-parametric Corrado's rank test successfully deals with any asymmetry, and cross-sectional dependence.

For any security i the market model for measuring normal returns is:

$$R_{i\tau} = \alpha_i + \beta_i R_{m\tau} + \varepsilon_{i\tau} \quad (3)$$

$$E(\varepsilon_{i\tau}) = 0 \quad \text{var}(\varepsilon_{i\tau}) = \sigma_{\varepsilon_i}^2 \quad (4)$$

where $R_{i\tau}$ and $R_{m\tau}$ are the period- τ return on security i and the market portfolio respectively; $\varepsilon_{i\tau}$ is the zero mean disturbance term; α_i, β_i are parameters.

I use ordinary least squares to estimate α_i, β_i , and $sd_{i\tau}$ (standard deviation of the error term) under the assumption that the error terms have an expected value of zero and are not correlated.

The abnormal return (AR_{it}) to security i for period τ is:

$$AR_{i\tau} = R_{i\tau} - \hat{\alpha}_i - \hat{\beta}_i R_{m\tau} \quad (5)$$

where $\hat{\alpha}_i, \hat{\beta}_i$ are estimated market model coefficients.

Thus, the AR is the disturbance term of the market model calculated on the output on the sample basis. Under the null hypothesis, H_0 : an event has no impact on the behavior of returns (mean or variance) the abnormal returns are distributed as:

$$\widehat{AR}_{it} \sim N(0, \sigma^2(\widehat{AR}_{it})) \quad (6)$$

I define the day "0" as the event day. For each security I use 250 daily return observations for the period around each event date. I start at day -250 and ending at day 0 relative to the each event. The first 220 days in this period (-250 through -30) is designated to "estimation window" (or "estimation period"), and the following 1 day is designated to the "event window" (or "event period"). In order to account for the possibility that event returns have influence on the normal return measure, the estimation widow and the event window do not overlap (MacKinlay, 1997).

4.2.2 Multivariate analysis-of-variance and multivariate regression model

It is also of interest to examine whether AR for periods around the event is equal to zero. First, if the event is partially anticipated, the AR behavior related the some particular event will show in the pre-event period (Kothari & Warner, 2004). Second, some events could have a lasting effect. Thus, it is of interest to estimate the behavior of post event-returns. To estimate the cumulative average abnormal returns (CAAR) I use multivariate regression model for the 250 observations to obtain the joint test across all firms I provide MANOVA.

I look at the different event "windows" framing short event window (Ball & Torous, 1988; MacKinlay, 1997; Schweitzer, 1989). The choice of the short against long window is based on several facts. First, Brown and Warner (1985) illustrated that a long event window severely reduces the power of the test statistic. Second, as noted by Konchitchki and O'Leary (2011), the use of a short window reduces the potential for a confounding event to effect market's response.

The event window for CAARs is designated in following ways. Paris conference took place from 30 November to 12 December. Such a long event period and negotiations between countries during this period make it hard to measure the effect of Paris agreement on firms' performance. Thus, we, first, take a last date of conference as an event date and estimate it using market model. Then, I provide MANOVA to obtain test for the joint significance of the

whole period of conference (11 days). To calculate the effect of presidential elections in the US I use CAR for 3 (-2; +2), 2 (-2; 1), 3 (-4; 1), and 2 (-1; +2) days.

I estimate coefficients by using OLS, the equation of interest is:

$$R_{N,t} = \alpha_N + \beta_N R_{m,t} + \gamma_N EPO_t + e_{N,t} \quad (7)$$

where γ_N is a dummy variable that takes the value of one during the event window and zero otherwise, which is allowed to differ across companies and measure the individual excess return during the event period. R_m - is a SP1200 index; EPO - equals to one during the event window and zero otherwise (Binder, 1985a, 1985b).

When the independent variables are the same for each N, the equation 7 can be disaggregated into a MVRM system of returns equations:

$$\left\{ \begin{array}{l} R_{1,t} = \alpha_1 + \beta_1 R_{m,t} + \gamma_1 EPO_t + e_{1,t} \\ R_{2,t} = \alpha_2 + \beta_2 R_{m,t} + \gamma_2 EPO_t + e_{2,t} \\ R_{3,t} = \alpha_3 + \beta_3 R_{m,t} + \gamma_3 EPO_t + e_{3,t} \\ \vdots \\ R_{N,t} = \alpha_N + \beta_N R_{m,t} + \gamma_N EPO_t + e_{N,t} \end{array} \right. \quad (8)$$

where γ_N are allowed to differ across firms and measure the individual excess return during the event period (CAAR).

One assumption of this approach is that the disturbances are independent and identically distributed within each equation, and can vary across equations. The advantages of the approach are in the hypothesis testing since contemporaneous dependence of the disturbances explicitly incorporated into the tests (Binder, 1985b).

Thus, there are a number of statistics available to test the joint hypothesis. Those are Wilks' lambda (Wilks, 1932), Pillai's trace (Pillai, 1955), Lawley-Hotelling trace (Hotelling, 1951; Lawley, 1938), and Roy's largest root (Roy, 1939). I note that each of statistics can be exactly distributed as F, approximately, or to show the upper bound of F. In our study all statistics are exactly F-distributed.

4.2.3 Panel data model

I examine the effect of news about RE policy on corporate performance. I use panel data model to obtain the average effect of the policy announcements on firms' performance

during the whole period of study. I provide tests to decide whether the fixed or random effects model, or pooled OLS is appropriate. I use Driscoll-Kraay standard errors (Cameron & Trivedi, 2010), which are assumed to be heteroskedastic, correlated between the groups, and is allowed to be serially correlated for m lags. I use Hausman test (Wooldridge, 2015) to determine whether I need to use fixed or random effects model. In this, I acknowledge that if I will use fixed effect model, the time invariant variables will be wiped out. Nevertheless, since I am mainly interested in the interaction effect (not main effect) this is not an issue. The results of all tests are listed in the A.5.

I denote EPO as a dummy variable for the policy announcement time period. The equation of interest is:

$$R_{i,t} = \beta_0 + \beta_1 R_{m,t} + \gamma_1 EPO_{i,t} + \alpha_{i,t} + e_{i,t} \quad (9)$$

where $\alpha_{i,t}$ is the unobserved firm effect or firm specific effect; $e_{i,t}$ is the error term. I note that if the pooled OLS is the most appropriate (we will test for the random effects - see Appendix A.5), the composite error will be $u_{i,t} = e_{i,t} + \alpha_i$, and the equation will be as:

$$R_{i,t} = \beta_0 + \beta_1 R_{m,t} + \gamma_1 EPO_{i,t} + u_{i,t} \quad (10)$$

The hurdle is that STATA (the statistical program used) provides Driscoll-Kraay standard errors just with pooled or fixed effect models. Nevertheless, if the tests show that the random effects model is the most appropriate, I still can use the pooled OLS, because under the random effects assumptions it will still provide consistent estimates (Cameron & Trivedi, 2010; Wooldridge, 2015). In this, if the random effects model is the most appropriate, I will show the results of both models, i.e. random effects model and pooled OLS. For brevity in the further discussion of the models, I will provide just the models with unobserved firm specific effect $\alpha_{i,t}$, nevertheless, the discussion of this paragraph applies to the all further model.

Second, I will estimate the effect of RE policy on the US RE firms given different firm-specific characteristics such as RE technology and firm size (measured by market capitalization). As I have mentioned in the previous chapter firms that produce biofuels are more diversified than firms within other RE technology. Such diversification could make biofuel firms less responsible to the policy announcement. In addition, the Chinese RE firms are within solar technology, therefore, it is of interest to measure whether solar firms

experience different effect of policy announcement than firms with other technologies (i.e. wind, geothermal, wave). Thus, I define two groups, one for solar and one for biofuel firms.

In addition, firms with different market capitalization could experience different effect of the policy announcements. In particular, small firms could be more sensitive to the policy announcements than big. Kothari and Warner (2004) in their study noted that individual firms' security variances and their abnormal return variances exhibit an inverse relationship to the firm size and can vary systematically by industry. "Small-firm effect" is when small firms appear to have higher average returns than large firms (Bodie et al., 2011). Originally, the small-firm effect was documented by Banz (Basu, 1983, 1997), who stated that small firms have a higher risk-adjusted return than large firms. Thus, the higher average returns of small firms could be justified by the additional risks borne in an efficient market (Chan, 1985). Thus, I define three groups for market capitalization, i.e. small, medium, and big.

I define firms with a big market capitalization as firms which have market capitalization between \$10 BN to \$200 BN; mid cap - ranging from \$2 BN to \$10 BN, this group of companies is considered to be more volatile than the big-cap; small cap - have a market capitalization less than \$2 BN.¹⁵

Thus, the equations of interest are:

a). Interaction with technologies:

$$R_{i,t} = \beta_0 + \alpha_i + \beta_1 R_{m,t} + \gamma_1 solar_i + \gamma_2 solar_i * EPO_{i,t} + \gamma_3 EPO_{i,t} + \gamma_4 biofuels_i + \gamma_5 biofuels_i * EPO_{i,t} + e_{i,t} \quad (11)$$

where the base group are firms within wind, wave, and geothermal technologies; γ_2 and γ_5 measures the differences of policy effect between solar firms and base group and biofuel firms and base group respectively; *solar* - equals unity for firms within solar technology, *biofuels* - equals unity for firms that produce biofuels.

b). Interaction with market capitalization:

$$R_{i,t} = \beta_0 + \alpha_i + \beta_1 R_{m,t} + \gamma_1 EPO_{i,t} + \sum_{i=2}^3 \beta_i M_{i,t} + \sum_{i=4}^5 \gamma_i M_{i,t} * EPO_{i,t} + e_{i,t} \quad (12)$$

where small firms are the base group; M - defines firms with different market capitalization (small, medium, big), e.g. equals one for firms with mid market capitalization and zero otherwise.

¹⁵ <http://www.investopedia.com/terms/m/marketcapitalization.asp>. Extracted: 25.04.2017.

As the last step of my study, I want to estimate whether policy affect differently the performance of Chinese and US firms.

c). RE firms China vs. US:

$$R_{i,t} = \beta_0 + \alpha_i + \beta_1 R_{m,t} + \gamma_1 USA_i + \gamma_2 USA_i * EPO_{i,t} + \gamma_3 EPO_{i,t} + e_{i,t} \quad (13)$$

where US equals to one for the US firms and zero otherwise; γ_2 measures the difference in policy effect between China and the US.

As a robustness check for the market model I specify Corrado's rank test. In addition, to check the robustness of the results of the effect of news about RE policy on the firms' performance, I use several different tests: (1) I use statistics provided together with multivariate analysis-of-variance (MANOVA), and (2) panel data model with Driscoll-Kraay standard errors.

5 Empirical results

In this chapter, I present the results of the effect of political events and policy announcements on energy firms' performance. First, I look at the effect of political events and discuss first three hypotheses. Then, I estimate the effect of policy announcements in both China and the US and discuss hypotheses 4-6. Next, I use a panel data model to test whether the effect of policy news on RE firms differs across two countries. Finally, I present the results of robustness check.

5.1 The effect of political events on RE and fossil firms

I have specified econometric models which aim to identify the impact of the political events on the price changes of RE and fossil firms. To estimate AARs I used market model and measured residuals. To obtain CAAR I estimate equation 7 and test joint significance of each event for group of firms using statistics from MANOVA. I checked for firm-specific announcements on the day of the event, if such announcements distorted final result, firm was deleted from the sample. Table 1 presents the average abnormal returns and cumulative average abnormal returns for three political events. In general, most firms did not react to the US 2012 presidential election and Paris agreement, while the US 2016 presidential election induced negative AARs for RE firms and positive for the US fossil firms.

Table 1: AARs and CAARs for political events

		The 2012 presidential election				
		AAR	$\hat{Y}_{(-2;1)}$	$\hat{Y}_{(-2;2)}$	$\hat{Y}_{(-4;1)}$	$\hat{Y}_{(-1;2)}$
China	RE firms	0.44 (0.010) $T_c=0.52$	0.86 (0.982)	-0.94 (0.838)	0.22 (0.834)	0.49 (0.822)
	Fossil firms	-1.21 (0.017) $T_c=0.22$	-1.44 (0.888)	-0.57 (0.987)	1.13 (0.976)	-0.79 (0.982)
The US	RE firms	-0.22 (0.010) $T_c=-0.48$	0.58 (0.620)	1.08 (0.199)	0.56 (0.891)	0.50** (0.025)
	Biofuel firms	0.36 (0.014) $T_c=-0.71$	1.13 (0.184)	1.25 (0.310)	0.67 (0.240)	1.54 (0.596)
	Fossil firms	-1.34*** (0.005) $T_c=-3.54$	-0.47 (0.164)	-0.64** (0.014)	-0.17 (0.161)	-1.24*** (0.001)
		The Paris agreement				
		AAR	$\hat{Y}_{(-12;1)}$			
China	RE firms	3.78*** (0.011) $T_c=3.40$	-	1.01 (0.156)	-	-
	Fossil firms ²	0.75 (0.880)	-	0.28 (0.454)	-	-
The US	RE firms	1.02 (0.019) $T_c=-0.37$	-	0.54 (0.871)	-	-
	Biofuel firms	-0.28 (0.005) $T_c=-0.83$	-	-0.41 (0.511)	-	-
	Fossil firms	-2.87*** (0.007) $T_c=-4.18$	-	-1.27*** (0.003)	-	-
		The 2016 presidential election				
		AAR	$\hat{Y}_{(-2;1)}$	$\hat{Y}_{(-2;2)}$	$\hat{Y}_{(-4;1)}$	$\hat{Y}_{(-1;2)}$
China	RE firms	-4.27*** (0.016) $T_c=-3.19$	-1.98 (0.482)	1.95 (0.261)	-0.92 (0.574)	-3.08* (0.073)
	Fossil firms	-0.55* (0.007) $T_c=-1.33$	-1.24 (0.568)	-1.87 (0.174)	-0.75 (0.852)	-1.85 (0.241)
The US	RE firms	-3.91** (0.018) $T_c=-2.21$	-1.83* (0.066)	-1.28*** (0.000)	-0.47 (0.231)	2.00*** (0.000)
	Biofuel firms	-1.64** (0.010) $T_c=-2.16$	-0.68 (0.164)	-0.44** (0.051)	-0.51 (0.108)	-0.83 (0.120)
	Fossil firms	5.27*** (0.008) $T_c=6.04$	2.39 (0.817)	1.48 (0.950)	0.97 (0.510)	2.50 (0.257)

AAR and CAAR presented in percentage ¹ Standard error (se) is in parenthesis; T_c states for the Corrado's rank test. For the estimates from equation 7, I provide p-value in the parenthesis. Statistically significant results are in bold * indicates the significance on 10% level, ** on 5%, *** on 1%. $\hat{Y}_{(-n;n)}$ are estimates of the equation 7; the subscript (-n; n) indicates the event window.² I measured the effect with the help of multivariate regression as there 2 firms with firm-specific information.

In particular in China, RE firms did not react to the US 2012 presidential election, and experienced positive AAR to the Paris agreement. RE firms obtained negative AAR as a result of the US 2016 presidential election. Fossil firms did not react to the first two of the political events, and obtained negative AR as a response to the US 2016 presidential election. In the US both RE and biofuel firms experienced negative AAR as a reaction to the US 2016 presidential election. US fossil fuel firms obtain negative AAR to both the US 2012 presidential election and the Paris agreement, and positive to the US 2016 presidential election, as seen from the Table 1.

There is a general pattern that CAAR reduces with event window increase. This indicates that the effect of the event wipes out with the period increase and the most significant is the day of the event.

5.1.1 Hypothesis 1: US RE companies reacted positively to the Obama's re-election, and fossil fuel companies experienced a negative effect

On the day after the US 2012 presidential election stock prices fell. Obama's re-election induced a sell-off in coal, gas and oil, and some of the alternative energy stocks. As can be seen from the Table 1 the AR for the US fossil firms declined on 1.34% as a reaction to the presidential election. $\hat{\gamma}_{(-2;1)}$ is not statistically significant for either of firms which means that the outcome of the election was not anticipated on the day prior to the announcement. The two-day $\hat{\gamma}_{(-1;2)}$ and three-day $\hat{\gamma}_{(-2;2)}$ CAAR are -1.24% and -0.64%, respectively, and are statistically significant. This indicates that the presidential election induced a lasting negative effect on the fossil firms. Such negative AARs and CAARs for fossil fuels firms are consistent with hypothesis 1.

There is a slightly negative AAR on the day of the announcement (even though the reaction is not statistically significant) for the US RE firms. CAARs surrounding the event day are positive and statistically significant just for the 3 days period (1; +3). This is because on the 08.11.2012 the AAR was high (2.00%), while remained statistically insignificant (se=0.016; Tc =0.631). US biofuel firms obtain positive AAR as a reaction for the event, but it is not statistically significant. This is inconsistent with the hypothesis 1.

While not statistically significant, but negative AARs for the US RE firms may be explained by: expiration of the government support for the RE and fears over fiscal policy.

Thus, in the US, one of the largest hurdles facing the RE industry is the termination of government support. Government grants and loan guarantees that were part of the stimulus were in 2012 basically over. The extension of tax credits, for example, which covered about

30% of a wind or solar projects' cost, were no longer sure. Thus, the wind industry's tax credit was set to expire at the end of the 2012. In addition, retaining tax credits for any type of energy was questionable, because of the difficulties to fight during negotiations over the federal budget and fiscal cliff (Hargreaves, 2012, November 13).

The sell-off of fossil and RE stocks may indicate that some shareholders were worried over fiscal policy. Norris and Schwartz (2012, November 7) argued that tax increases and spending cuts, known as the fiscal cliff, could push the economy into recession in 2013.

Both RE and fossil firms in China did not experience statistically significant abnormal returns as a reaction to the event. This implies that there is no spillover effect of presidential election to the Chinese firms.

The bottom line is that, while many investors had already factored in the likelihood of Obama's win and polls had been indicating for some time that President Obama was likely to win, the fall in returns for fossil fuel firms indicate that expectation was not shared by all market participants (Norris & Schwartz, 2012, November 7).

5.1.2 Hypothesis 2: RE firms reacted positively to the Paris agreement of 2015, while fossil firms experienced a negative effect

The only two groups of firms which reacted statistically significant to the Paris agreement were the US fossil firms and Chinese RE firms, while the AARs of other groups of firms are not statistically significant. Thus, the US fossil firms obtained negative AAR (2.87%) and CAAR (-1.27%). The Chinese RE firms obtained positive AARs of 3.78%. Such results are partially consistent with the hypothesis 2. In addition, the US RE firms also obtained positive AARs of 1.02%, even though not statistically significant.

As I discussed in the sub-chapter 3.2, there are two answer of why the reaction was so heterogeneous. First, results indicate that the event was anticipated at least by some part of the market participants. During the negotiations the deal got a lot of attention from both media and scholars. Even before the countries agreed on the deal, scholars within the game theory, for example, were trying to forecast of whether the Paris 2015 UNFCCC negotiations would be successful (Stokman & Thomson, 2015). In addition, such a long estimation period (for the period of 12 days) could be contaminated by confounding factors. Thus, the results could capture the noise. Nevertheless, negative AARs for US fossil fuel firms, positive AARs for the Chinese RE firms, and the market behavior on the event day indicate that the agreement was important.

The bottom line is that the negative AARs for US fossil fuel firms and positive AARs for the Chinese RE firms indicate that despite the fact that Paris 2015 UNFCCC negotiations is a slowly occurring event, and got big coverage from media, the expectation of market participants over whether the deal is likely to happened was not shared by all market participants.

5.1.3 Hypothesis 3: (a) US RE firms reacted negatively to the US 2016 presidential election and fossil firms reacted positively. (b): The election affected Chinese firms

Both US RE and fossil firms reacted to the result of the US 2016 presidential election. Such results are consistent with the hypothesis 3. In addition, we observe a negative reaction of the Chinese RE firms to the event. In particular, as shown from the last 5 rows of Table 1 both US RE and biofuel firms obtained negative abnormal returns of 3.91% and 1.64% respectively. The CAAR around the event is also negative and statistically significant for the period of 2 (-2; 1), 3(-2; 2), and 3(-1; 3) days respectively, which are -1.83%, -1.28%, and -2.00% respectively. The biofuel firms also obtain negative CAAR, nevertheless, the statistically significant just for 3(-2; 2) days period, i.e. -0.44%. The US firms obtain positive AARs of 5.27%, And positive abnormal returns surrounding the event, even though such returns are not statistically significant. While the US 2016 presidential election was the most unpredictable event of all 3, I note the behavior of returns on pre event period.

Chinese fossil firms do not react to any of the political event (at least on the 5% level of significance). This could be the result of the selected sample: Chinese fossil firms are mainly mid and large cap firms. Taking into account "firm size effect" (Chang, 1998; Kothari & Warner, 2004; Reinganum, 1981), such a reaction (or not reaction) may be explained by the firm-specific characteristics.

On the other hand, a negative reaction to the US 2016 presidential election (statistically significant of the 10% level) may also be explained by the Donald Trump's policy of "protectionism". In particular, he proposed to levy a 45% tax on Chinese imports, and labeled China as a currency manipulator. Chinas state-owned giants such as PetroChina Co. and China Petroleum & Chemical Corp. (which are in my sample) long viewed the US stable regulatory and political climate important for their global deal making. After the election the Chinese energy sector was uncertain over Donald Trump as president and his new policy. Higher level of political risk is associated with investing in the US in the eyes of many Chinese energy executives (Neate et al., 2016, October 8; Spegele, 2016, November 13).

I note that on the last event CAARs for the US fossil fuel firms are big, but not statistically significant. Given such high CAARs I provided the robustness check of the results by using the panel data method with the Driscoll and Kraay standard errors for the last event. The results are similar, as can be seen from the Table 4 in the sub-chapter 5.3.

5.2 The effect of policy announcements on firms' performance

I have specified several econometric models which aim to identify the impact of the news about RE policy on price changes of RE and fossil firms. First, I use Panel data to estimate the effect of policy announcements on the firms' performance during the whole period of the study. In particular, I estimate equations 9(10)-13, which are provided in chapter 4.

I estimate models by OLS and GLS methods. This choice is justified based on the statistical tests (see A.5). I have provided Hausman test, Breusch and Pagan LM test for the random effects, a Lagrange Multiplier test for serial correlation, Pasaran CD (cross-sectional dependence) test. The results of the all tests are provided in appendix A.6. The results of the tests suggest that the random effect model is the most appropriate for the study. A Lagrange Multiplier test for serial correlation indicates that there is no problem with the first order serial correlation. Nevertheless, the Pasaran CD test indicates that there is dependence across firms. I can, then, use Pooled OLS with the Driscoll and Kraay standard errors, as they, take into account problems with cross-sectional correlation.

Wooldridge (2015) and Cameron and Trivedi (2010) suggest that pooled estimators are consistent if the random effects model is appropriate. Nevertheless, to show that the estimators are similar, we provide random effect models with cluster robust standard errors. The results of estimates can be found in the Table 3.

5.2.1 Hypothesis 4: News about RE policy affected RE firms positively

First, I estimate the equation 9(10) to obtain the effect of RE policy announcements on the firms' performance. In general, policy announcements affect RE firms, as can be seen from the first column of the Table 2. This is consistent with the hypothesis 4. The effect of the policy is also statistically significant for the period of 2 days (-2; 1) and for the period of the three days (-2; +2). This means that the governmental announcements about RE policy were anticipated on the preceding day of the actual announcement. Nevertheless, the effect of the policy decreases with the time period increase.

In particular across the groups, announcements about RE policy positively affect RE firms in both US and China. The effect of the policy on the biofuel firms in the US although

positive, is not statistically significant on the day of the announcements, but statistically significant for the period of 2 days (1;-2) this implies that the announcements are likely to be anticipated by the market participants.

Table 2: The effect of the policy announcements on the performance of firms

Event window	RE firms in both the US and China	China		US			
		RE firms	Fossil firms	RE firms	Biofuels firms	Fossil firms	RE + biofuels firms
		$\hat{\gamma}_1$	$\hat{\gamma}_1$	$\hat{\gamma}_1$	$\hat{\gamma}_1$	$\hat{\gamma}_1$	$\hat{\gamma}_1$
(+2;-2)	0.51*** (0.002)	0.97** (0.003)	0.10 (0.001)	0.07 (0.002)	0.49 (0.004)	-0.02 (0.001)	0.24 (0.002)
(1;-2)	0.84*** (0.002)	1.42** (0.003)	0.08 (0.002)	0.44 (0.003)	0.65** (0.002)	0.02 (0.002)	0.51** (0.002)
0	1.34*** (0.003)	2.44*** (0.005)	0.47 (0.003)	0.77* (0.004)	0.49 (0.004)	-0.19 (0.002)	0.70** (0.003)
N	33	9	7	13	11	28	24

The coefficient represented in the percentage. Statistically significant results are in bold * indicates the significance on 10% level, ** on 5%, *** on 1%.

The effect of policy on US RE firms is smaller than on Chinese and insignificant for biofuel firms on the day of the policy announcement. So, why are they different? First, while Chinese RE firms are in generally small firms (just one firm can be categorized as a mid size in the period of 2013-2016), US RE firms have different market capitalizations. Second, while Chinese firms are within solar power industry, US firms include different types of the RE technology (see A.1).

In this connection, I am interested in how firms with different firm-specific characteristics are affected by the announcements. I take the day "0" as an event day because the effect of the policy for the periods (-2; 1) and (-2; 2) are not statistically significant for US RE firms. In addition, the effect on the Chinese RE firms decreases with period increase, as can be seen from the Table 3.

Thus, according to the estimates from the equation 11 (Table 3) both the interaction term between policy announcements and solar firms, and the interaction term between policy announcements and biofuel firms, while positive, are not statistically significant. Thus, we can conclude that policies do affect differently firms that specialize on the different RE sources, but such differences are not statistically significant. In particular, the effect of the policy announcements on the biofuel firms is not statistically different from the effect of the policy announcements on the other firms (wind, geothermal, wave).

Table 3: Estimates from the pooled OLS and random effects model

Variables	Pooled OLS			RE effects model		
	US		RE firms China vs. US	US		RE firms China vs. US
	Equation 11	Equation 12	Equation 13	Equation 11	Equation 12	Equation 13
SP1200	1.25*** (0.048)	1.25*** (0.048)	1.41*** (0.054)	1.25*** (0.093)	1.25*** (0.093)	1.41*** (0.091)
EPO	0.75 (0.005)	1.03** (0.004)	2.40*** (0.005)	0.74** (0.003)	1.04*** (0.003)	2.41*** (0.003)
mid		0.17*** (0.0004)	0.17*** (0.0004)		0.20*** (0.001)	0.17*** (0.0004)
big		0.19*** (0.001)	0.016*** (0.0004)		0.17*** (0.001)	0.16*** (0.001)
solar	-0.04 (0.001)			-0.04 (0.001)		
solar*EPO	0.06 (0.007)			0.06 (0.005)		
biofuels	-0.01 (0.001)			-0.01 (0.001)		
biof*EPO	-0.24 (0.006)			-0.23 (0.001)		
mid*EPO		-1.17** (0.005)			-1.17*** (0.001)	
big*EPO		-0.94* (0.005)			-0.96*** (0.001)	
EPO*US			-1.70*** (0.006)			-1.70*** (0.004)
US			-0.05 (0.001)			-0.048 (0.001)
N	29848	29848	41047	29848	29848	41047

* The coefficient represented in the percentage. Statistically significant results are in bold * indicates the significance on 10% level, ** on 5%, *** on 1%.

We estimate the equation 12 to analyze whether the effect of the policy announcements depends on the market capitalization. According to the estimates (see Table 3) the interaction terms between market capitalization and policy announcements are negative and statistically significant. The base group in the model is firms with small market capitalization. Thus, we can conclude that policy effect is stronger for firms with small market capitalization.

Thus, the results are consistent with the hypothesis 4: RE firms reacted positively to the RE policy announcements.

5.2.2 Hypothesis 5: The performance of fossil firms was *not* affected by the news about RE policy

Next, I estimate the effect of the RE policy announcements on the fossil firms. As can be seen from the Table 2 both Chinese and US fossil firms did not react statistically significant to RE policy announcements. These results are consistent with the hypothesis 5 and indicate that RE policy announcements are irrelevant for the market participants in making their decision to invest in the fossil fuel firms. As I discussed in the chapters 2 and 3, fossil firms constitute the largest share of the primary energy consumption, receive the largest amount of the investments, and given such dominance of fossil fuels, they will still remain the backbone of the world's energy consumption (Höök & Tang, 2013). Thus, our results indicate that fossil fuels do not perceive RE as a substantial competitor.

5.2.3 Hypothesis 6: Chinese RE policy had stronger effect than US policy

The last step in the analysis is to examine whether the policy of China affect differently Chinese RE firms than US policy affect US RE firms. We estimate the equation 13 using panel data, the results of the model provided in the Table 3. To provide such results we control for the firm size effect (as has been discussed above firms with different market capitalization react differently to the policy announcements). The results show that the differences in the effect of policy announcement between two countries are statistically significant. In particular, Chinese RE firms react stronger to the policy than US RE firms, which is consistent with the hypothesis 6.

5.3 Robustness check

I conduct a robustness check by providing several tests and different models. Both MANOVA and panel data model gives similar test statistics for the announcements on the day 0, as can be seen from the Table 5. In addition, I provide the Corrado's rank test to control for the issues with non-normality and cross-sectional dependence. The result is depicted together with outcomes of the market model (see Table 1); the test results are similar to the t-test.

Table 4: The robustness check of the results for the US 2016 presidential election

US fossil firms	The 2016 presidential election				
	AAR	$\hat{Y}_{(-2;1)}$	$\hat{Y}_{(-2;2)}$	$\hat{Y}_{(-4;1)}$	$\hat{Y}_{(-1;2)}$
Fossil firms	5.27*** (0.001)	2.33 (0.208)	1.43 (0.015)	0.96 (0.0127)	2.45 (0.0120)

$\hat{Y}_{(-n;n)}$ are estimates of the equation 9; the subscript (-n; n) indicates the event window. Coefficients are presented in the percentage term. Statistically significant results are in bold * indicates the significance on 10% level, ** on 5%, *** on 1%.

Table 5: The robustness check of the results for the effect of policy announcements on firms' performance

Event window	China				US					
	RE firms		Fossil firms		RE firms		Biofuels firms		Fossil firms	
	$\hat{\gamma}$	F-test	$\hat{\gamma}$	F-test	$\hat{\gamma}$	F-test	$\hat{\gamma}$	F-test	$\hat{\gamma}$	F-test
0	2.27***	3.17	0.46	0.77	-	-	0.49	0.68	-0.24	1.27
N	9		7		-		11		28	

Coefficients are presented in the percentage term. Statistically significant results are in bold * indicates the significance on 10% level, ** on 5%, *** on 1%. There is no estimate for RE firms due to non-overlapping event window for some firms within the group.

6 Discussion and policy implications

6.1 Political events

I selected three important political events which could potentially shift RE policy and affect performance of energy firms: the 2012 presidential election in the US, the Paris agreement on climate change, and the 2016 presidential election in the US. The results show that political events do affect stock market. In particular, the US 2012 presidential election affected US fossil firms negatively, the Paris agreement affected US fossil firms negatively and Chinese RE firms positively, and the US 2016 presidential election affected RE and biofuel firms negatively and US fossil firms positively. In general, the results are partially consistent with hypothesis 1-2, and fully consistent with the hypothesis 3. The results are broadly consistent with previous studies, which show that political events affect stock market (Bouoiyour & Selmi, 2017; Kabiru et al., 2015).

Fossil firms did react negatively to US 2012 presidential election, while both RE and biofuel firms did not react at all. In contrast to Ramiah et al. (2015b), who found the spillover effect of the US 2008 presidential election on the Asian stock market, Chinese companies did not respond to the US 2012 presidential election. This might be because Obama did not change his policy view towards China. Similarly, Murtaza et al. (2015) did not find any impact of the US 2012 presidential election on the stock market return of Pakistan.

The result of the effect of Paris agreement is not fully consistent with the hypothesis 2. While other studies (Sandalow et al., 2016) have argued that an agreement has the potential to significantly influence climate finance, the only two groups that reacted statistically significant to the agreement were Chinese RE and US fossil firms. The US RE firms reacted positively and experienced AAR of the 1%, but the AAR was not statistically significant.

According to the EMH such differences in the reaction may be attributed to the partial anticipation of the outcome (Binder, 1985a; Bodie et al., 2011).

The US 2016 presidential election was a true surprise to most political observers and the market. My results are consistent with the hypothesis 3 and other studies. In particular, Bouoiyour and Selmi (2017) argues that the Trump victory divided the US stock markets into two main groups, winners and losers. In addition, I have found that the event had a spillover to the Chinese firms.

The results have huge implications towards financial market, and show which events affect positively and which affect negatively energy sector. The market reaction to the chosen political events depends on the event at hand and, hence, the information made during election campaign and negotiations about climate change are useful for valuing the securities in the market.

In the case of the presidential elections, the political event signals changes in governmental policy. Policies established by the governing president affect the ability of businesses and the general economy to prosper. Changes in the governmental policy lead to changes in priorities towards particular industries, creating winners and losers. For example, the US 2016 presidential election signaled changes in priorities from RE to fossil fuels for the US. Thus, the effect of an event was positively depicted on the firms that heavily involved in fossil fuels and negatively on the RE firms. This might lead to the decrease in the investments in RE.

6.2 News about RE policy

The results on the effect of news about RE policy on performance of energy firms are of particular interest to the policymakers and investors. First, firms heavily involved in fossil fuels, the main source of CO₂ emissions, did not react negatively to the news about RE policy. This might imply that the RE sector is not regarded as a significant competitor to fossil fuels. Second, market participants take into account news about RE policy when evaluating their investments in the RE sector. This means that RE policy is successful in promoting investments in RE sector. Third, the effect of policy is different between the US and the Chinese policy. In particular, the effect of the policy is stronger in China than in the US. This might be a result either of the stronger signals sent to the market by China's government, or by more open US political system.

The results are consistent with Ramiah et al. (2013), who indicated that the biggest polluters are not affected by the introduction of green policy. Given the EMH, this result mainly suggests that news about RE policy are irrelevant to fossil firms. In this connection, given that the production of energy from fossil fuels is projected to increase (together with overall increase in consumption of energy) (OECD, 2012), RE may not be regarded as a challenging competitor to the fossil fuel. In addition, larger firms are more diversified and incorporate gradual shift towards renewables into their strategy and are not dictated by day-to-day news. Given rationality of market participants, this implies that news about RE policies are not considered negatively to the fossil firms.

RE sector experiences positive abnormal returns to the RE news, which implies that market participants follow news about RE policy in both China and the US. Taking EMH into account, the obtained results implies that news are both unanticipated (at least for some part of the market participants) and relevant. In contrast to the previous studies which, evaluate green and environmental policy (Ramiah et al., 2015b) on environmental friendly industry, I do find the AAR generated by the RE firms. Such differences could be explained by the fact that studies of (Ramiah et al., 2015b) chose the day when green policies are announced (e.g. Sustainable Community and Climate Protection Act) which, as I have already discussed might be fully anticipated. In addition, the study analyzed the effect on the environmental-friendly industries, without taking RE companies as a separate group.

Consistent with previous results on the effect of news announcements on the stock market, e.g., the effect of environmental news on food industry (Deak & Karali, 2014), I have found a significant positive effect of news on RE firms. Given rationality of market participants, this implies that news about RE policy are considered positive for RE firms performance, and that they were not fully anticipated.

According to the results, the effect differs between firms with different market capitalization and between different sources of RE. The first result is referred to as the firm size effect, and has been investigated by many scholars (Bodie et al., 2011; Chang, 1998; Reinganum, 1981). According to the firm size effect the average returns are higher on the small-size firms. This can be explained by the fact that smallest firms tend to be riskier (Bodie et al., 2011). In addition, larger firms are more diversified. The results of the study show that policy announcements affect larger firms with small market capitalization than firms with mid and big capitalization.

The last result of interest relates to the effectiveness of news about RE policy between different countries. As far as I know, there is no similar study undertaken before. I find that Chinese firms are more affected by the news about policy announcements than US firms.

Taking EMH into account this means that Chinese policy news are either more relevant or less anticipated than US policy. First, the announcements of federal government in the US could be less relevant than those made by central government in China. As already discussed in the background chapter, US federal government heavily relies on the policies of different states (Campbell, 2014). In addition, US policy is characterized by shifting policies and changing priorities (Elliott, 2011), and the off-on saga of important financial incentives (BNEF, 2016; Mendonca et al., 2009). This could make US policy less relevant to the companies within different states than China's policy.

Second, announcements of federal government in the US could be more anticipated than in the China, given that US policy system is more open than in China.

6.3 Limitations and suggestions for further research

The main limitation of the study is the small sample size. Due to the limited number of RE firms traded on US stock exchange, during the period of the study (especially Chinese). This makes it difficult to give an estimation of external validity of the study. Nevertheless, internal validity is satisfied. In addition, Chinese firms traded on the Hong Kong market are not in the sample (due to specifications of market regulations). I would advice for further research to provide a study on both markets to obtain richer data. In the case of the US I would advice to examine the effect of state level policies on the energy industry.

While I observed the reaction of market participants to the news about RE policy which were modeled as dummy variables, many of policy instruments have numerical values (such as financial incentives). Incorporating these values would shed further light on what is effective and to what extent.

7 Conclusion

The aim of this study was to investigate the impact of recent political events and news about RE policy on performance of the firms within energy industries in China and the US. To provide this study I used EMH and event study methodology. The EMH states that to affect stock prices news should be unanticipated and relevant. In general, results suggest that the stronger reaction of market participants was on the day 0, with subsequent decreases of

the estimates with timing period increase. For some groups I have found significant cumulative average abnormal returns. This means, first, that some events were anticipated by the market, and second, events had a long-lasting effect.

The results indicate that the effect of political events depends on the event at hand and on industry. In particular, market participants take into account presidential campaign and climate change negotiation. Heterogeneity of obtained results could indicate that not all market participants share the same expectations or have different ways of responding to market news.

In addition, the results indicate that market participants follow news about RE policy in making their decision to buy or sell RE shares, but news do not affect fossil fuel sector. This indicates that while RE policy encourage investments into RE firms, fossil firms do not perceive RE industry as a substantial competitor. I found that Chinese firms are more affected by the news about policy announcements than US firms. This could be of two reasons: first, US political system is more open, thus, the news are partially anticipated; second, the US announcements might be less relevant than Chinese.

The results of study are of interest for both policymakers and financial market participants. For policymakers, the awareness of the effect of their policies on performance of firms is helpful in carrying out a policy framework that will hinder or stimulate investments in energy firms.

For investors, changes in policy and in government lead to policy and political risk, therefore, this study is helpful in carrying out a more accurate risk management. In particular, RE firms in China are more sensitive to the policy announcements, thus, investors should pay more attention to the China's RE policy while considering investments in their RE firms.

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Appendix

A.1

Table 6: Firms taken in the sample

N	Firms	Sector	Country
1	Renesola	Solar power	China
2	Trina solar	Solar power	China
3	JinkoSolar Holding	Solar power	China
4	Yingli Green Energy Holding	Solar power	China
5	Daqo New Energy	Solar power	China
6	Semiconductor Manufacturing International	Solar power	China
7	JA Solar Holdings	Solar power	China
8	Highpower International	Solar energy storage systems	China
9	Canadian Solar	Solar power	China
10	Sinopec Shanghai Petrochemical	Refined oil	China
11	PetroChina	Gasoline, Oil	China
12	CNOOC	Oil and gas	China
13	China Petroleum and Chemical	Oil and gas	China
14	Yanzhou Coal Mining	Coal	China
15	Recon Technology	Oil services	China
16	Gulf Resources	Oil and gas	China
17	Future Fuel	Biofuels	US
18	Archer-Daniels-Midland	Biodiesel, Ethanol	US
19	Bunge Limited	Ethanol	US
20	Darling ingredients	biofuels	US
21	Ormat Technologies	Thermal	US
22	Owens Corning	Wind	US
23	U.S. Geothermal	Geothermal	US
24	Power REIT	Acquiring real-estate interests related to RE	US
25	Sunwork	Solar power	US
26	SunPower Corp.	Solar power	US
27	Renewable Energy Group	Biofuels	US
28	Green Plains	Ethanol	US
29	Gevo	Renewable chemicals and advanced biofuels	US
30	First Solar	Solar	US
31	Applied Materials	Solar products	US
32	The Andersons	Ethanol	US
33	Amyris	Renewable fuels	US
34	Amtech Systems	Solar cells	US

N	Firms	Sector	Country
35	American Superconductor	Renewable solutions	US
36	Aemetis	Renewable fuels and biochemicals	US
37	Advanced Energy Industry	Solar PV	US
38	Ocean Power Technologies	Tidal energy	US
39	Pacific Ethanol	Ethanol	US
40	Real Goods Solar	Solar	US
41	Adams Resources and Energy	Hydrocarbon	US
42	Alon USA Energy	Heavy crude oil refineries	US
43	Apache	Oil and gas	US
44	Anadarko Petroleum	Oil and gas	US
45	Atwood Oceanics	Offshore driller	US
46	Bill Barrett	Oil and gas	US
47	Buckeye Partners	Liquid petroleum products	US
48	Camber Energy	Drilling	US
49	Chesapeake Energy	Oil and gas	US
50	Cummins Inc.	Fuel, diesel	US
51	Callon Petm	Oil and gas	US
52	CONSOL Energy	Gas exploration	US
53	Clayton Williams Energy	Oil and gas	US
54	Cloud Peak Energy	Coal producer	US
55	Chevron	Oil and gas	US
56	ConocoPhillips	Oil and gas	US
57	Devon Energy	Oil and gas	US
58	Cimarex Energy	Oil and gas	US
59	Cabot Oil and Gas	Oil and gas	US
60	Alliance Holdings GP	Coal	US
61	Approach Resources	Drilling for oil and gas	US
62	Carrizo Oil and Gas	Oil and gas	US
63	Dawson Geophysical	Seismic services	US
64	Sanchez Production Partners	Oil and gas	US
65	Yuma Energy	Oil and gas	US
66	Barnwell Industries	Oil and gas	US
67	Abraxas Petroleum	Oil and gas	US
68	Cobalt International Energy	Oil and gas	US

A.2

Table 7: RE policy announcements in China and the US

N	Date	Event
China		
1.	24.09.2012	Recommendations to further develop financial support to PV industry.
2.	11.11.2012	China is planning to expand pilot programs for promoting the domestic use of photovoltaic power generation by launching a batch of new pilot projects before the year's end.
3.	19.12.2012	Measures announced by China's cabinet intended to boost the country's struggling PV sector.
4.	08.01.2013	The announcement of China's energy authority on RE power generation. China remains the world's largest energy producer for a fifth year in 2012.
5.	04.06.2013	China's top legislature establishes an inspection team to oversee the implementation of the Law on Renewable Energy.
6.	15.07.2013	Development guideline of the State Council of China
7.	23.07.2013	China's government issued specific standards for RE development and Reform Commission issued distributed photovoltaic power tariff.
8.	11.08.2013	China will speed up development of the energy-saving sector and make it a pillar of the national economy by 2015.
9.	30.08.2013	Government announcement of a subsidy to entities with generate power using solar panels.
10.	29.09.2013	China's Ministry of Finance announced that it will offer tax breaks to manufacturers of solar power products, in the country's latest effort to encourage the use of the green energy.
11.	17.12.2013	China's Standardization Administration announced a stricter quality standard for petrol.
12.	16.01.2014	For 2014 National Energy Agency (NEA) set target to add 14 GW of new solar capacity of which 8 GW will be distributed. The target is divided per provinces. The provinces shall not overshoot the targets given in order to receive national subsidies for solar PV.
13.	10.02.2014	China will aim to increase the share of non-fossil fuels in its overall energy consumption to 10.7 percent in 2014, in an effort to further improve its energy mix.
	17.04.2014	Government to support clean energy and reduce coal dependence. China will improve energy production and consumption modes to raise the level of green, low-carbon and sustainable development in the energy industry, in an attempt to battle air pollution.
14.	10.06.2014	China's taxation authorities announced that buyers of distributed PV power should invoice for purchases, a move to reduce the tax burden on PV power producers and promote green energy.
15.	23.09.2014	China pledged to take a firm actions on climate change and reduce its emission of carbon per unit GDP by 45%
16.	22.05.2015	China, the biggest renewable-energy investor, has asked local authorities to ensure the purchase of all the clean power generated in the country.
17.	15.09.2015	China will eliminate obstacles for using wind and solar power by deepening reform in its electricity system
18.	21.12.2015	The central bank plans to introduce green bonds to allow financial institutions to raise funds for green projects.
19.	24.02.2016	The BRICS Bank is likely to extend the first batch of loans and offer the first bond in the second quarter of this year. Zhu Xian, vice-president and chief operations officer of NDB, said each of the projects to be appraised will be valued at more than \$100 million. NDB's projects to run in China will also focus on renewable energy, excluding nuclear energy.

20.	26.01.2016	China expects more financial support in the shape of "green loans" that help enterprises improve energy efficiency and boost trade of pollution discharge right
21.	20.03.2016	Subsidies for green sectors such as photovoltaic and new energy cars are necessary, said Miao Wei, minister of industry and information technology, at the China Development Forum.
	01.06.2016	China will implement a series of policies and measures to drive clean energy development and deployment in an effort to promote harmony between people and nature, the Seventh Clean Energy Ministerial
22.	04.12.2016	'Green' sector to be 3% of GDP by 2020.
	19.12.2016	The central government has earmarked new energy vehicles, new energy, energy-saving and environmental protection technology, one of the key emerging industries of strategic importance in China. The government will provide policy support for managerial improvements, strengthen intellectual property rights and offer financial assistance to these industries.
The US		
1.	08.02.2012	Energy Department announces over \$12 million to spur solar energy innovation.
2.	17.02.2012	The Department's ARPA-E issues a Request For Information (RFI) regarding the development of technologies to support transformational research and development for advanced management strategies for Energy Storage Systems.
3.	01.03.2012	Energy Secretary announced that an initial \$20 million will be available this year as the first step in supporting up to four innovative offshore wind energy installations across the US.
4.	13.03.2012	The Department holds a closed-door meeting at the White House with executives from more than 30 major companies focusing on the tax-related benefits of partnering with renewable-energy developers. + President Obama announces that the US, Japan, and the European Union are filing a complaint with the World Trade Organization against China for its export restraints on its near-monopoly rare earth metals that are used by American manufacturers to make a wide variety of products, including hybrid car batteries, wind turbines, energy-efficient lighting, steel, advanced electronics, automobiles, petroleum, and chemicals.
5.	13.06.2012	Secretary Steven Chu today announced a new competition and investments to make it easier and cheaper for utilities, businesses and consumers to deploy clean, renewable solar energy.
6.	24.04.2012	As part of the Energy Department's SunShot Initiative, U.S. Energy Secretary Steven Chu today announced up to \$5 million available this year to develop "plug-and-play" photovoltaic (PV) systems that can be purchased, installed and operational in one day.
7.	29.08.2012	The Energy Department announced five new research projects to accelerate innovations that could lower the cost of photovoltaic and concentrating solar power technologies.
8.	12.12.2012	US Energy Secretary Steven Chu announced seven offshore wind awards for projects in Maine, New Jersey, Ohio, Oregon, Texas and Virginia.
9.	30.01.2013	As part of the Energy Department's SunShot Initiative, the Department announced seven data-driven projects to unearth new opportunities for reducing costs and accelerating solar energy deployment in the US.
10.	10.04.2013	US Deputy Secretary of Energy Daniel Poneman detailed President Barack Obama's \$28.4 BN Fiscal Year 2014 budget request for the Energy Department. Poneman emphasized the President's commitment to an all-of-the-above energy strategy that prioritizes investments in innovation, clean energy technologies, and national security.
11.	20.06.2013	Energy Department announces new research center to boost clean energy technologies on a smarter grid.
12.	26.06.2013	The White House releases "state-by-state reports" detailing the impacts of extreme

		weather and pollution across the country. The reports also detail how the plan will help cut carbon pollution and prepare states for the impacts of climate change that can't be avoided. The White House also responds to criticism of the plan, noting that “some of the nation’s biggest polluters are attacking the President’s plan to cut carbon pollution and meet the climate change challenge, and they’re recycling the same tired and empty arguments that we’ve heard time and time again.”
13.	29.08.2013	The Energy Department announced \$16 million for seventeen projects to help sustainably and efficiently capture energy from waves, tides and currents.
14.	22.10.2013	Energy Secretary Moniz announced about \$60 million to support innovative solar energy research and development.
15.	25.11.2013	The Department of Energy announced up to \$30 million in Advanced Research Projects Agency – Energy (ARPA-E). Renewable generation technologies, such as solar and wind, pose a fundamental challenge to centralized power generation due to variability and intermittency. In addition, centralized generation frequently requires long transmission distances that result in power losses and leave lines susceptible to disruption during natural disasters. Many of these challenges can be mitigated through a distributed system, where power is generated in close proximity to the end-user.
16.	12.12.2013	Energy Department announces \$150 million in tax credits to invest in US clean energy manufacturing.
17.	17.04.2014	The Energy Department announced \$15 million to help communities develop multi-year solar plans to install affordable solar electricity for homes and businesses.
18.	20.06.2014	Secretary Moniz announced \$3.2 million to launch the National Incubator Initiative for clean energy, which will create a national support network to serve the clean energy small business and entrepreneur community, providing critical technical assistance and training services in order to bring these businesses and entrepreneurs closer to market readiness.
19.	01.07.2014	The Department of Energy announced the first step toward issuing a \$150 million loan guarantee to support the construction of the cape wind offshore wind project.
20.	17.07.2014	The Energy Department announced up to \$31 million to establish the initial phases of the frontier observatory for research in geothermal energy, a field laboratory dedicated to cutting-edge research on enhanced geothermal systems.
21.	17.09.2014	The Department of Energy announced expansions of its clean energy Manufacturing Initiative in support of the American manufacturing sector and a new initiative to support President Obama’s goal of doubling energy productivity by 2030.
22.	22.10.2014	Energy Department announced \$53 million to drive innovation, cut cost of solar power
23.	29.01.2015	Energy Department announced more than \$59 million investment in solar. The funding will help lower the cost of going solar and enable businesses to develop solutions for overcoming technical, regulatory, and financial challenges, further unleashing cost-competitive solar energy.
24.	02.05.2016	Energy Department announced \$25 million to accelerate integration of solar energy into nation’s electrical grid
25.	19.05.2015	Energy Department releases report, where it evaluates potential for wind power in all 50 States.
26.	26.05.2015	The Energy Department announced \$32 million in funding to help train American workers for the solar energy workforce and to further drive down the cost of solar by developing innovative low-cost concentrating solar power collectors and increasing access to critical solar data.
27.	24.08.2015	President Obama announced more than one billion dollars in Department of Energy initiatives to drive innovation and accelerate the clean energy economy.
28.	16.09.2015	Energy Department Announces \$102 Million to Tackle Solar Challenges, Expand

		Access to Clean Electricity
29.	23.11.2015	The US Department of Energy and Israel's Ministry of National Infrastructure, Energy and Water Resources announced \$5.1 million for six newly selected clean energy projects as part of the Binational Industrial Research and Development Energy program.
30.	20.01.2016	The Department announced the 16 collegiate teams selected to participate in the Department of Energy Solar Decathlon 2017 competition. The teams, from colleges and universities across the United States and around the world, will now begin the nearly two-year process of building solar-powered houses that are affordable, innovative and highly energy-efficient.
31.	18.05.2016	The Energy Department released the On the Path to SunShot reports, a series of eight research papers examining the state of the US solar energy industry and the progress made to date toward the SunShot Initiative's goal to make solar energy cost-competitive with other forms of electricity by 2020.
32.	19.07.2016	President Obama is committed to ensuring that every American family can choose to go solar and to cut their energy bills – and that every American community has the tools they need to tackle local air pollution and global climate change.
33.	26.07.2016	Energy Department announced and \$9.8 Million in Funding to Support the Future of Hydropower in the US.
34.	31.08.2016	The Energy Department announced \$29 million in funding under the Frontier Observatory for Research in Geothermal Energy program.
35.	09.09.2016	Energy Secretary Moniz and Interior Secretary Jewell announce new national offshore wind strategy.
36.	12.03.2012	The Department's Savannah River Site near Aiken dedicates \$795 million Biomass Cogeneration Facility.
37.	22.03.2012	The White House announced up to \$35 million over three years to support research and development in advanced biofuels, bioenergy and high-value biobased products.
38.	06.04.2012	The Energy Department announced up to \$15 million available to demonstrate biomass-based oil supplements that can be blended with petroleum, helping the US to reduce foreign oil use, diversify the nation's energy portfolio, and create jobs for American workers.
39.	14.09.2012	The Environmental Protection Agency announced that it requires refiners to blend 1.28 BN gallons of bio-based diesel into the nation's fuel supply in 2013. The requirement for 2012 was one billion gallons.
40.	09.09.2013	The Department's Office of Inspector General releases a follow-up audit of the Bioenergy Technologies Office program supporting the development of biomass resources into commercially viable biofuels, bioproducts, and biopower. The IG finds that, despite over 7 years of effort and the expenditure of about \$603 million, Department of Energy had not yet achieved its biorefinery development and production goals.
31	01.08.2013	Secretary Moniz Announces New Biofuels Projects to Drive Cost Reductions, Technological Breakthroughs
42.	12.05.2014	The Department's Ames Laboratory announces the creation of a faster, cleaner biofuel refining technology that not only combines processes, it uses widely available materials to reduce costs.
43.	17.07.2014	The US Department of Energy and the US Department of Agriculture announced the selection of 10 projects that will receive funding aimed at accelerating genetic breeding programs to improve plant feedstocks for the production of biofuels, biopower, and bio-based products.
44.	17.10.2014	Energy Secretary Ernest Moniz delivered remarks about need of biofuels, and its government support.
45.	12.04.2016	The US Department of Energy's Advanced Research Projects Agency-Energy announced up to \$60 million in funding for two new programs that aim to solve

		some of the nation's most pressing energy challenges by accelerating the development of novel energy technologies.
46.	14.07.2016	The Energy Department announces up to \$15 million for three projects aimed at reducing the production costs of algae-based biofuels and bioproducts through improvements in algal biomass yields.

A.3 Aggregation of abnormal returns

In order to drive overall inference of the event, I aggregate ARs. There are two dimensions in aggregation: through time and across security (MacKinlay, 1997; Schweitzer, 1989).

The cross-section average abnormal returns are calculated by summing the abnormal returns and dividing by the number of firms. (Schweitzer, 1989) argue that the average that the average takes into account the possibility that the event may have different impact across firms.

$$AAR_{\tau} = \sum_{i=1}^N \frac{AR_{i\tau}}{N}$$

where AAR_{τ} is the average abnormal returns for period τ ; N is a number of firms.

Define cumulative abnormal returns (CAR) as the sum of the abnormal returns (AR) within the event period:

$$\widehat{CAR}_i(\tau_1, \tau_2) = \sum_{\tau=\tau_1}^{\tau_2} AR_{i\tau}$$

where τ_1 and τ_2 denotes the interval of event period.

Define average CAR across firms:

$$CAAR(\tau_1, \tau_2) = \frac{1}{N} \sum_{i=1}^N \widehat{CAR}_i(\tau_1, \tau_2)$$

$CAAR(\tau_1, \tau_2)$ is the average CAR for period t , and shows the impact of the event over time (Schweitzer, 1989). If the market does not anticipate the event, the CAAR up to the event date should be approximately zero.

A.4 The Corrado's RANK test

Corrado (Aktas et al., 2007) introduced a test based on the ranks of AR. Corrado's rank test, which does not require the cross-sectional distribution of the excess returns to be symmetrical, takes the magnitude of the excess returns into consideration. According to this test, I sort ARs and assign a rank to each day.

$$K_{it} = \text{rank}(AR_{it}), \quad t = -250, \dots, 0$$

where K_{it} is the rank assigned to firm i 's AR on day t .

Then, the rank test is:

$$T_{\text{corrado}} = \frac{\frac{1}{N} \sum_{i=1}^N (K_{ie} - \bar{K})}{S(K)}$$

where \bar{K} is the average rank, K_{ie} rank across the i stocks on the event window, and $S(K)$ is the standard error.

$$S(K) = \sqrt{\frac{1}{T + TE} \sum_{t=1}^{T+TE} \frac{1}{N^2} \sum_{i=1}^N (K_{it} - \bar{K})^2}$$

TE : number of days within the event period; T : number of days within the estimation period; N : number of firms in the sample.

The use of ranks neutralizes the impact of the shape of AR distribution (e.g., its skewness and kurtosis, and the presence of outliers). This statistic is distributed asymptotically as unit normal.

A.5 Stata tests

Test for normality in AR

1) The US 2012 presidential election

US fossil firms

Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
ar	28	0.92687	2.208	1.631	0.05144

US RE firms

Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
ar	13	0.94888	0.900	-0.206	0.58149

US biofuel firms

Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
ar	11	0.83778	2.626	1.888	0.02954

China fossil firms

Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
ar	7	0.60180	5.230	3.445	0.00029

China RE firms

Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
ar	9	0.91377	1.267	0.404	0.34314

2) The Paris agreement

US fossil firms

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. swilk ar if dif==0
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Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
ar	28	0.99204	0.240	-2.935	0.99833

US RE firms

Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
ar	13	0.86064	2.455	1.759	0.03928

US biofuel firms

Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
ar	11	0.98200	0.291	-1.982	0.97625

China RE firms

Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
ar	9	0.79950	2.946	2.051	0.02015

China fossil firms

Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
ar	7	0.98270	0.227	-1.905	0.97160

3) The US 2016 presidential election

US fossil firms

Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
ar	28	0.97418	0.780	-0.512	0.69570

US RE firms

Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
ar	13	0.84762	2.684	1.934	0.02655

US biofuel firms

Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
ar	11	0.93693	1.021	0.037	0.48508

China RE firms

Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
ar	9	0.92863	1.049	0.079	0.46838

China fossil firms

Shapiro-Wilk W test for normal data

Variable	Obs	W	V	z	Prob>z
ar	7	0.89277	1.408	0.555	0.28942

Test for multivariate regression model

US fossil firms

Breusch-Pagan test of independence: $\chi^2(378) = 36370.114$, Pr = 0.0000

US biofuel firms

Breusch-Pagan test of independence: $\chi^2(55) = 1112.375$, Pr = 0.0000

US RE firms

Breusch-Pagan test of independence: $\chi^2(78) = 1228.654$, Pr = 0.0000

China fossil firms

Breusch-Pagan test of independence: $\chi^2(21) = 4308.517$, Pr = 0.0000

China RE firms

Breusch-Pagan test of independence: $\chi^2(36) = 6154.058$, Pr = 0.0000

Stata tests for panel data

RE firms

US RE firms

1) Random effect

Test: $\text{Var}(u) = 0$
 $\text{chibar2}(01) = 27.27$
Prob > $\text{chibar2} = 0.0000$

2) Serial correlation

Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
 $F(1, 12) = 0.045$
Prob > F = 0.8360

3) Cross-sectional dependence

Pesaran's test of cross sectional independence = 20.329, Pr = 0.0000
Average absolute value of the off-diagonal elements = 0.071

4) Hausman test

Test: Ho: difference in coefficients not systematic
 $\chi^2(2) = (b-B)'[(V_b-V_B)^{-1}](b-B)$
= 1.55
Prob> $\chi^2 = 0.4601$

US biofuel firms

1) Random effect

Test: $\text{Var}(u) = 0$
 $\text{chibar2}(01) = 5.70$
Prob > $\text{chibar2} = 0.0085$

2) Serial correlation

Wooldridge test for autocorrelation in panel data

H0: no first-order autocorrelation

F(1, 10) = 0.014

Prob > F = 0.9097

3) Cross-sectional dependence

Pesaran's test of cross sectional independence = 24.678, Pr = 0.0000

Average absolute value of the off-diagonal elements = 0.102

4) Hausman test

Test: Ho: difference in coefficients not systematic

chi2(2) = (b-B)'[(V_b-V_B)^(-1)](b-B)

= 0.39

Prob>chi2 = 0.8223

Solar and biofuel firms

1) Random effect

Test: Var(u) = 0

chibar2(01) = 30.54

Prob > chibar2 = 0.0000

2) Serial correlation

Wooldridge test for autocorrelation in panel data

H0: no first-order autocorrelation

F(1, 23) = 0.056

Prob > F = 0.8156

3) Cross-sectional dependence

Pesaran's test of cross sectional independence = 37.252, Pr = 0.0000

Average absolute value of the off-diagonal elements = 0.070

4) Hausman test

Test: Ho: difference in coefficients not systematic

chi2(4) = (b-B)'[(V_b-V_B)^(-1)](b-B)

= 1.79

Prob>chi2 = 0.7746

US market capitalization

1) Random effect

Test: Var(u) = 0

chibar2(01) = 21.18

Prob > chibar2 = 0.0000

2) Serial correlation

Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
F(1, 23) = 0.055
Prob > F = 0.8167

3) Cross-sectional dependence

Pesaran's test of cross sectional independence = 37.340, Pr = 0.0000
Average absolute value of the off-diagonal elements = 0.071

4) Hausman test

Test: Ho: difference in coefficients not systematic

$$\begin{aligned} \text{chi2}(5) &= (b-B)' [(V_b - V_B)^{-1}] (b-B) \\ &= 1.60 \\ \text{Prob} > \text{chi2} &= 0.9016 \end{aligned}$$

China RE firms

1) Random effect

Test: Var(u) = 0
chibar2(01) = 0.00
Prob > chibar2 = 1.0000

2) Serial correlation

Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
F(1, 8) = 3.084
Prob > F = 0.1172

3) Cross-sectional dependence

Pesaran's test of cross sectional independence = 66.258, Pr = 0.0000
Average absolute value of the off-diagonal elements = 0.313

4) Hausmann test

Test: Ho: difference in coefficients not systematic

$$\begin{aligned} \text{chi2}(2) &= (b-B)' [(V_b - V_B)^{-1}] (b-B) \\ &= 0.74 \\ \text{Prob} > \text{chi2} &= 0.6902 \end{aligned}$$

China vs. US RE firms

1) Rnadam effect

Test: Var(u) = 0
chibar2(01) = 12.20
Prob > chibar2 = 0.0002

2) Serial correlation

Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
F(1, 32) = 0.207
Prob > F = 0.6525

3) Cross-sectional dependence

Pesaran's test of cross sectional independence = 73.222, Pr = 0.0000

Average absolute value of the off-diagonal elements = 0.095

4) Hausmann test

Test: Ho: difference in coefficients not systematic

$$\begin{aligned} \text{chi2}(4) &= (b-B)' [(V_b-V_B)^{-1}] (b-B) \\ &= 1.89 \\ \text{Prob}>\text{chi2} &= 0.7557 \end{aligned}$$

US + China

1) Random effect

Test: Var(u) = 0
chibar2(01) = 21.35
Prob > chibar2 = 0.0000

2) Serial correlation

Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
F(1, 32) = 0.211
Prob > F = 0.6487

3) Cross-sectional dependence

Pesaran's test of cross sectional independence = 73.491, Pr = 0.0000

Average absolute value of the off-diagonal elements = 0.095

4) Hausmann test

Test: Ho: difference in coefficients not systematic

$$\begin{aligned} \text{chi2}(2) &= (b-B)' [(V_b-V_B)^{-1}] (b-B) \\ &= 1.15 \\ \text{Prob}>\text{chi2} &= 0.5632 \end{aligned}$$

Fossil fuel firms

US fossil firms

1) Random effect

Test: Var(u) = 0
chibar2(01) = 1.35
Prob > chibar2 = 0.1231

2) Serial correlation

Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
F(1, 27) = 0.353
Prob > F = 0.5573

3) Cross-sectional dependence

Pesaran's test of cross sectional independence = 151.587, Pr = 0.0000
Average absolute value of the off-diagonal elements = 0.225

4) Hausmann test

Test: Ho: difference in coefficients not systematic

$$\text{chi2}(2) = (b-B)' [(V_b - V_B)^{-1}] (b-B)$$
= 0.62
Prob>chi2 = 0.7320

Chinese fossil firms

1) Random effect

Test: Var(u) = 0

chibar2(01) = 0.00
Prob > chibar2 = 1.0000

2) Serial correlation

Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
F(1, 6) = 1.176
Prob > F = 0.3198

3) Cross-sectional dependence

Pesaran's test of cross sectional independence = 33.551, Pr = 0.0000
Average absolute value of the off-diagonal elements = 0.216

4) Hausmann test

Test: Ho: difference in coefficients not systematic

$$\text{chi2}(2) = (b-B)' [(V_b - V_B)^{-1}] (b-B)$$
= 1.83
Prob>chi2 = 0.3997



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